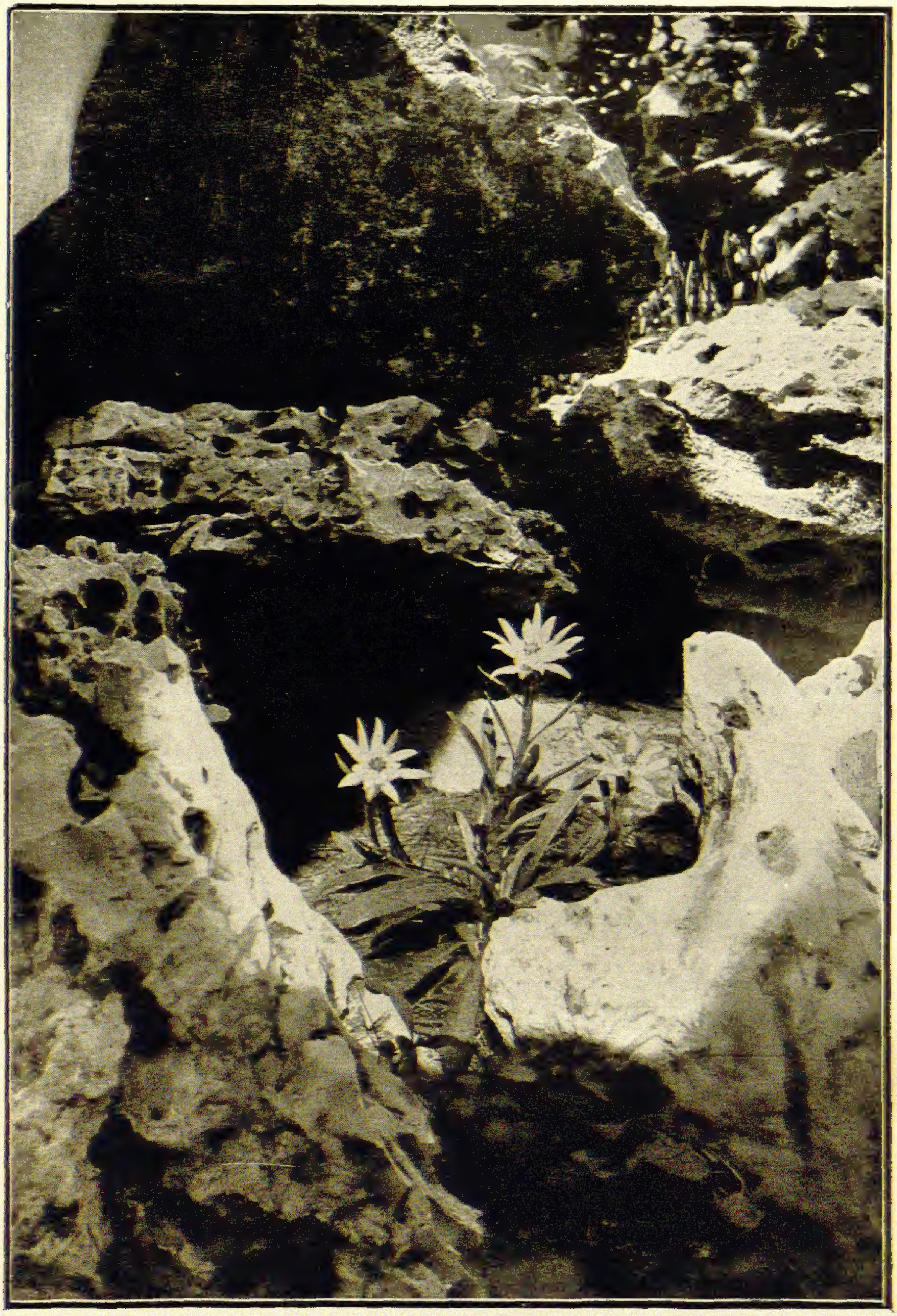

EDELWEISS, IN THE ROCKERY.

MISSOURI

BOTANICAL GARDEN.

SEVENTH ANNUAL REPORT.

ST. LOUIS, MO.:
PUBLISHED BY THE BOARD OF TRUSTEES.
1896.

MISSOURI BOTANICAL
GARDEN LIBRARY

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CYRUS P. WALBRIDGE,
Mayor of the City of St. Louis.*

A. D. CUNNINGHAM, Secretary.

* *Ex-officio.*

[1] Elected January 8, 1896, to succeed Dr. Geo. J. Engelmann, who resigned in November, 1895, having met with the Board since December, 1889.

[2] Elected April 10, 1895, to succeed Geo. S. Drake, who resigned in February, 1895, having met with the Board since April, 1890.

[3] Elected President of the School Board, March 12, 1896, in place of Frederick W. Brockman, who had met with the Board since November, 1893.

[4] Elected President of the Academy of Science, January 6, 1896, to succeed Dr. John Green, who had met with the Board during 1895.

PREFACE.

Under direction of the Board of Trustees, the seventh annual report of the Missouri Botanical Garden is presented to the public. The sixth report was issued May 3, 1895.

The reports of the Garden are sent regularly to scientific institutions and journals in exchange for publications or specimens desirable for the library, herbarium, or plant-houses of the Garden. So far as possible reprints of the botanical articles which they contain are sent to botanists occupied with a study of the same subjects.

Any of the Garden publications not out of print may be purchased, at approximately the cost of publication, from Dr. A. E. Foote, of Philadelphia, the Cambridge Botanical Supply Co., of Cambridge, Mass., W. Wesley & Son, of London, R. Friedländer & Sohn, of Berlin, or the undersigned.

WILLIAM TRELEASE.

St. Louis, Apr. 2, 1896.

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AESCULUS PARVIFLORA.

REPORTS FOR THE YEAR 1895.

REPORT OF THE OFFICERS OF THE BOARD.

SUBMITTED TO THE TRUSTEES JANUARY 8TH, 1896.

To the Board of Trustees of the Missouri Botanical Garden:

The financial results for the past year have been entirely satisfactory. The receipts from rentals have exceeded those of the previous year over $4,500.00.

All houses vacant at the beginning of the year have been rented, and at present all the properties of the Board are occupied at satisfactory rentals with the exception of two small dwellings, yielding jointly $37.00 per month.

All necessary repairs have been made during the year upon the properties of the Board, and they can be considered in fairly good condition; many of them, however, are very old and rapidly decaying and require constant attention to keep them in tenantable condition.

The Garden has been kept in good condition, some improvements have been made in the arrangement of the Garden and Fruticetum, and valuable additions have been made to the collection of plants. The extension of the water system of the Garden, begun in 1890, has been carried on during the year, and now the entire Garden is fully supplied with water for irrigation purposes.

In the 33d Section of the 4th Clause of Mr. Shaw's will, he expressed the desire that a small cottage be provided as a residence for a man, to be employed, whose duty it should be to keep in order the Mausoleum and the grove and the grounds around it, which the Board have carried out by erecting south of the main entrance to the Garden,

near what is known as the Museum gate, a beautiful and artistic stone building at a cost of about $4,500.00, which is used in the manner which Mr. Shaw intended.

A large portion of the estate left by Mr. Shaw, located west of Grand Avenue, has been for years a burden to the Board by reason of the constantly increasing taxes, being largely in excess of the income, which though small can not be increased, as its uses will not justify an advance in the rentals, it being used for market gardening. In view of this fact the Board decided at its June meeting to make every possible effort to increase the revenue from this property by utilizing it in accordance with the wishes of Mr. Shaw, in the 3d Section of the 1st Clause of his will, "by leasing upon building leases for a term of not exceeding sixty years," and in order to test this matter fully a desirable piece of property was selected fronting on Flora Avenue between Grand and Tower Grove Avenues. Plats were made and advertisements inserted in the daily papers from July 1st to October 7th, and a large number of posters distributed, offering this property for perpetual lease for terms of sixty years at prices based on a very small percentage of the present cash value of the property, with restrictions as to buildings, etc., renewable at the end of sixty years on a basis of 3 per cent. on the cash value of the ground at that time; but the efforts were fruitless, not an application being received. We feel that the leasing of this property for residence purposes has been fully tested and has been a failure, and other measures must be used to utilize this and other property for revenue purposes.

We have received during the past year from the Public Administrator $17,670.00 on account, and according to his final settlement, to which the Board have excepted, there remains yet in his hands $4,301.82 belonging to the estate.

Additions have been made to the library and herbarium by donations and purchase, and permanent improvements made at the Garden, and the following sums have been

credited to the stock account, which now aggregates $1,517,333.78:—

Library (purchases and donations)	$7,324 54
Herbarium (purchases and donations)	1,563 50
Missouri Botanical Garden, permanent improvements	9,889 56
	$18,777 60

After carrying out Mr. Shaw's will as to banquets, sermon, and premiums to flower show, and caring for the Garden and the properties of the Board, we carry forward a gain for the year of $13,344.56.

For a full and detailed account of the receipts and expenditures you are referred to the following statement:—

RECEIPTS.

Rents	$97,868 90	
Stock Account, paid by Administrator	17,670 00	
Garden, pasturage, sales, etc	1,519 09	
Interest, dividends, and cash discounts on taxes.	2,094 25	
Garden hand-book sales	79 50	
Publication sales	15 92	
Loss by fire to buildings	28 20	$119,275 86
Cash balance Jan. 1st, 1895		20,405 03
Total		$139,680 89

EXPENDITURES.

Garden Account,		
Labor, including garden pupils	$13,321 92	
Fuel	1,275 52	
Stable and Implements	374 95	
Repairs and Supplies	1,920 45	
Care of Lodge for pupils, and supplies	650 09	
Plants and Seeds	1,532 27	
Herbarium	1,191 82	
Library, books, subscriptions, etc	4,975 42	
Garden Office, salaries, supplies, etc	4,889 32	
Research, chiefly salaries	871 10	$31,002 86
Garden Improvements Account,		
Gate House, Green-houses, Water pipe, etc	10,985 52	10,985 52
Publication Account,		
Annual Volume	1,275 31	1,275 31
Property Expense Account,		
Taxes, State, City, School and Sprinkling	24,309 32	
Streets, pavements and sewers	145 61	
Insurance	4,509 45	
Repairs	5,889 67	
Improvements	700 00	35,554 05
Office Account,		
Salaries	3,560 00	
Rent of office	840 00	
Printing, postage and telephone	470 73	
Advertising, sale of leaseholds, and vacant property	710 53	5,581 26
Sundry Accounts,		
Legal Expenses	1,738 95	
Repairs to buildings damaged by fire	28 20	1,767 15
Bequests,		
Premium to Flower Show	481 00	
Flower Sermon	200 00	
Trustees' Banquet	813 05	
Gardeners' Banquet	356 45	
Washington University, School of Botany	143 65	1,994 15
		$88,160 30
Invested in 1895		40,035 08
Cash on hand December 31, 1895		11,485 51
Total		$139,680 89

The books of the Board have been closed after showing the operations for the year ending Dec. 31st, 1895, and the receipts have been disposed of as follows: —

Rent account		$97,868 90
Interest		2,094 25
Garden hand-book		79 50
		$100,042 65

CONTRA.

Garden expense	$29,483 77	
Garden improvements	11,086 52	
Office expense	5,581 26	
Repairs	5,889 67	
Insurance	4,509 45	
Taxes	24,309 32	
Streets, pavements and sewers	145 61	
New improvements	700 00	
Legal expenses	1,738 95	
Washington University	143 65	
Flower sermon	200 00	
Trustees' banquet	813 05	
Gardeners' "	356 45	
Flower show	481 00	
Publications	1,259 39	
Surplus for 1895	13,344 56	
	$100,042 65	$100,042 65

Surplus to December 31, 1894	$60,473 93
" for 1885	13,344 56
Total surplus, December 31st, 1895	$73,818 49

Respectfully submitted,

R. J. LACKLAND, President.

Attest:

A. D. CUNNINGHAM, Secretary.

SEVENTH ANNUAL REPORT OF THE DIRECTOR.

SUBMITTED TO THE TRUSTEES JAN. 8, 1896.

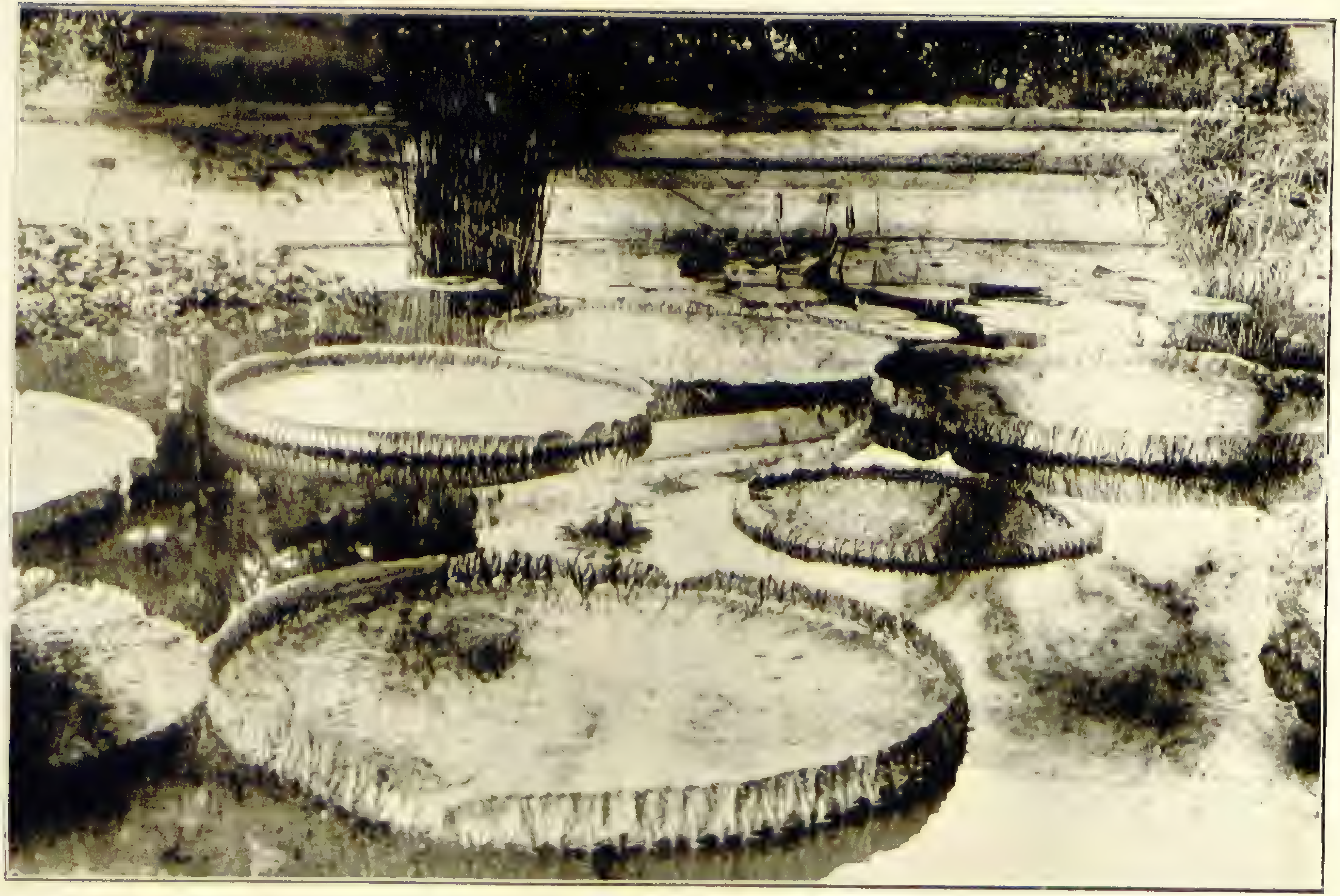
To the Board of Trustees of the Missouri Botanical Garden:

In compliance with the rules of the Board, the following report on the Missouri Botanical Garden and the Henry Shaw School of Botany is respectfully submitted.

THE BOTANICAL GARDEN.

So far as can be estimated, about one-third more people visited the Garden in 1895 than in 1894, owing largely to the frequent newspaper references to the Amazon Water-lilies of the Garden and Park. On the two open Sundays, when count was kept, the aggregate number was likewise in excess of previous years. On the June Sunday, with a temperature of 96.5° F., only 12,921 persons passed the gates, but on the September Sunday, which was in every way favorable to visitors, 30,151 persons were counted. As in previous years, these Sunday visitors were orderly, and showed no disposition to vandalism. During the year, 318 copies of the Handbook of the Garden have been purchased at the gate.

On the whole, the decorative features of the Garden were of the same character as in the preceding year. A considerable number of species of hardy plants was added, especially in the arboretum, along the wall south of the Museum Gate, and in the annular beds to the north of the observatory in the center of the Garden, where the herbaceous plants are in approximate botanical sequence. At the east of the observatory two sections were devoted to a collection of hardy plants of decorative value. The Garden now contains 301 named species of trees, 561 of shrubs, 1,129 of hardy perennial herbaceous flowering plants, of



VICTORIA REGIA.

which 74 are grasses and 178 Compositae, and 39 of hardy ferns, etc.

The Victoria pond constructed in 1894* was improved in the early spring by a rearrangement of the hot water apparatus by which it is heated, and through the summer and early fall scarcely a week passed in which one or more flowers of the *Victoria regia* did not open, while the large leaves were a source of even greater wonder to visitors. On several occasions the Garden was kept open in the evening for the benefit of persons wishing to see the flowers expand, which happens in the twilight, and the vicinity of the pond was then lighted with such appliances as were at hand; but the cultivation of two plants of the same species in Tower Grove Park, near the Tower Grove Avenue entrance, and consequently very near the Garden, made it unnecessary to defer the time of closing the latter as a rule, since the Park is open during the evening. In addition to the *Victoria* and the related large leaved but small flowered Gorgon Plant (*Euryale ferox*), a considerable number of pond lilies were grown attractively in the granitoid ponds near the greenhouses and in the small pond made some years since in the northwestern part of the arboretum. At present, 35 named species or varieties of aquatic and tender marsh phanerogams are growing at the Garden.

Owing largely to changes which have been made gradually during the last year or two, by which a more intelligent class of labor is being acquired, the gardening operations have this year been more satisfactory than before, a fact even more noticeable in the greenhouses than outside. Indeed, at no time since I assumed the direction of the Garden have the houses been so attractive as they are this winter. This has encouraged me to add to the collection of greenhouse plants more extensively than heretofore, and among other things a small but carefully selected collection of orchids has been placed in the house built in 1894, so

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* Sixth Report, 13.

that with good management there will scarcely be a time during the year when one or more of these interesting plants cannot be found in bloom, while in the latter part of the winter a considerable number are open together. This collection will be extended considerably from year to year, my intention being to devote the greater part of this house to a varied collection of orchids. The Garden now has in cultivation 156 named species or varieties of greenhouse orchids, 93 of aroids, 65 of palms, 11 of cycads, 224 of foliage plants, 51 of Yuccas, Dracaenas, Furcraeas, etc., 22 of Ficus, 194 of plants yielding useful products, 217 of plants cultivated for their flowers, 526 of succulents, of which 91 are Agaves, 306 are Cacti, and 93 are aloids, Mesembryanthemums, and Cotyledons, and 12 sorts of Nepenthes, and 84 of ferns and the like.

In 1895 a system of recording accessions to the collection of plants at the Garden was adopted, modeled after that in use at Kew, for details of which I am indebted to the Director and Mr. Nicholson. In this plan each accession receives a serial number written as a numerator over the abbreviation of the year (e. g., the last accession for 1895 was $^{278}/_{95}$), and is entered in this abbreviated form, with indication of date, source, origin either by donation or purchase, and approximate valuation, in a check book in the Director's office, while each accession, in addition to these items, has a recorded list of species and varieties entered in extenso in an accession book kept by the Head Gardener. The label of each plant is then marked with this indicative fraction, which is also noted on all correspondence pertaining to the accession, and on herbarium specimens which may be made subsequently, so that the record of a given plant is readily ascertained at any time by reference to the books and letter file. The total number of named species and varieties, other than annuals, cultivated at the end of 1895, was 3,921.

As in previous years, a considerable number of bedding plants were removed from the ground and potted on the

approach of cold weather, and about 800 of these were distributed to hospitals, mission schools and similar charities, about half of the number going to the kindergartens of the public school system, in all of which places they have done good. A part of this potted material has also been reserved for exchange purposes.

In the early spring, a much needed extension of the water supply of the grounds was effected under the direction of Professor J. B. Johnson, this extension making possible the provision of water closets in place of the earth closets placed in the arboretum,* besides adding greatly to the facility and certainty with which the garden lawns and beds are watered.

The steam plant by which the herbarium and museum buildings and the Director's residence are heated † having proved wasteful of fuel because the pipes were laid too near the surface of the ground, a renovation of the entire system was made during the autumn, under the direction of Professor J. H. Kinealy. Unfortunately, the absence of deep sewers in the vicinity of the Garden makes it impossible to drain the boiler pit and similar excavations, so that a considerable amount of labor is expended each year in freeing them from water, but with this exception the steam plant is believed now to be in good working order.

Early in the season, the possibility of combining the numerous fire holes of the greenhouses in the center of the Garden ‡ was also referred to Professor Kinealy, on whose report the Board decided that the cost of providing a central boiler plant, with the piping changes necessitated by the consolidation, would be so much greater than the evident saving in labor in firing for the houses now heated as to render it undesirable for the present to attempt such a consolidation.

The fruticetum,§ or more properly orchard, in which 1,550 feet of drain tile was laid in 1890, while in the follow-

* Second Report, 21.
† Second Report, 23.
‡ Third Report, 13.
§ Sixth Report, 14.

ing year 210,600 square feet was subsoiled and planted with an experimental orchard comprising 68 varieties of fruit, was further improved in 1894 by the removal of the old and worthless apple trees and grape vines and the laying of 1,630 feet of tile; and during the past season many additional varieties of fruit were planted, and the walks were heavily dressed with cinders and edged with sod. Along the principal walks radiating from the center of this inclosure* have been placed hedges of low growing fruit-bearing shrubs, such as *Elaeagnus*, *Prunus pumila*, *Berberis Thunbergii*, *Ribes*, etc.

During the summer, a forcing house, measuring 20x60 feet, was built in the vegetable garden on the model of the usual commercial houses, the walls being double boarded and the intervening space filled with cinders, while heat is supplied by hot water under pressure. This house has been divided by removable partitions into a vegetable house and two graperies, one intended for Black Hamburg and the other for Muscat of Alexandria,— which requires either a higher temperature or a longer period of forcing. With these adjuncts, the horticultural instruction of garden pupils will be carried on more satisfactorily than heretofore, by its extension in a direction in which commercial gardening is each year making considerable advances. At present, 167 named species or varieties of fruit plants, and 34 named vegetables, are in cultivation.

Owing to the exclusion of seeds from the mail intended for foreign countries, except at letter rates, which are prohibitive, very few seeds were distributed to correspondents in 1895, but notwithstanding this the list of accessions shows that many seeds were received from Europe, Australia, Central America, etc., in exchange for the reports of the Garden or as donations. A few consignments of spare plants have been made to other institutions in this country, from some of which adequate return has been received.

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* First Report, map.

COTTAGE AT MUSEUM-GATE.

Among the donors of plants to the Garden in 1895, I wish particularly to mention Professor Sargent, of the Arnold Arboretum, who has supplied us with nearly 500 correctly named species or varieties of hardy plants, for the most part of Japanese origin.

In compliance with the desire expressed in the thirty-third paragraph of the fourth clause of Henry Shaw's will, a cottage has been erected on the grounds just within the Museum Gate, which is occupied by an employee whose duty it is to keep in order the mausoleum, the museum building, the grove, and the grounds around. This cottage is so placed that when the number of visitors to the Garden shall have become considerably greater than it now is, the occupant may also act as gate-keeper for the Museum Gate, and a waiting room for ladies has been reserved in it. It is connected with a bell button at this gate, which has been marked for the present as for the Director's residence only, by direction of the Board, since the need for opening the gate to the public is not now great enough to justify the employment of an attendant's time.

The herbarium has been increased by the incorporation of 10,635 sheets of specimens, of which 4,465 were purchased and 6,170 were received by donation or exchange. Three mounted duplicates from the Engelmann herbarium, as well as 484 unmounted duplicates, have been distributed in exchanges. As now constituted, the mounted herbarium contains the following collections:—

The Engelmann herbarium (all groups), about........		97,800	specimens.
The general herbarium of higher plants:—			
The Bernhardi herbarium................	61,120		
Other specimens	64,976		
		126,096	"
The collection of Thallophytes:—			
The Bernhardi herbarium................	126		
Other specimens........................	18,140		
		18,266	"
Making a total of about................		242,162	
Valued at................................			$24,216.20

For a number of years, wood specimens, thin veneers of wood, and mounted slides, largely of woods, have been accumulating at the Garden. These specimens, assignable to the capital stock account of the Secretary as adjuncts of the herbarium, are now inventoried as follows: —

Wood specimens of various sizes	1,027,	valued at $100 00
Wood veneers, by Spurr, Hough, Nördlinger, and Michel	2,229,	" " 150 00
Microscope slides, by Penhallow, Hough, Munroe, and others	1,051,	" " 250 00
Together	4,307,	" " $500 00

In 1895, $3,764.00 was spent for purchases and binding for the library, which has been increased by 1,150 books and 147 pamphlets purchased, and 314 books valued at $603.15, and 961 pamphlets valued at $196.82, donated or received in exchange for the publications of the Garden. Early in the season, a few of the drawings and preliminary sketches of the late Paulus Roetter, the delineator of the Cactaceae for Engelmann's classical work on that group, were purchased of his daughter, and have been bound in a volume which is placed beside the Engelmann MSS. in the library. After a number of efforts to place an exact valuation upon the Sturtevant Prelinnean library,* this collection has been arbitrarily appraised at $5.00 per volume,— a low average,— and will be added to the capital stock account by the Secretary, with the accessions for the year. The work of indexing the plant illustrations in the library has been continued through the year, 36,057 cards, mainly of this class, having been added.

As now constituted, therefore, the library contains: —

Pamphlets	10,930		
Books (general)	9,095	valued at	$32,294 23
" (Sturtevant)	463	" "	2,315 00
" (Engelmann, MSS.)	60	" "	600 00
" (Roetter, MSS.)	1	" "	100 00
Total	20,549	" "	$35,309 23
Index cards	146,057	" "	1,460 57

* Fourth Report, 14; Fifth Report, 16; Sixth Report, 16.

In the spring, Mr. Smith, who had acted as Botanical Assistant at the Garden, was appointed to a better paid position in the Division of Agrostology of the United States Department of Agriculture, and in July his place was taken by Mr. C. H. Thompson, who had previously acted as General Instructor in the School of Botany. Through the year Mr. H. C. Irish has served as Horticultural Assistant, Miss Grace E. Johnson as artist, Miss Eva M. Reed as indexer, and Mr. C. E. Hutchings as amanuensis.

During the year a small amount of time has been found by myself and my principal assistants for research work, the results of which, so far as completed, have been contributed to societies or journals or will shortly be published.

The table which the Garden has maintained for some years at the Wood's Holl Biological Laboratory, was discontinued at the end of 1894, at the wish of the Board.

As in previous years, a number of botanists and horticulturists from a distance have visited the Garden and made use of its collections, and parts of the herbarium material have been sent away for the use of specialists.

It has always been my wish, and the intention of the Board, that the facilities which are rapidly accumulating at the Garden should be as fully used as possible by resident and visiting investigators as well as the employees of the Garden, and in May last the following circular was distributed generally to American botanists and reprinted by several of the scientific journals:—

The attention of botanists is called to the facilities afforded for research at the Missouri Botanical Garden. In establishing and endowing the Garden, its founder, Henry Shaw, desired not only to afford the general public pleasure, and information concerning decorative plants and their best use, and to provide for beginners the means of obtaining good training in botany and horticulture, but also to provide facilities for advanced research in botany and cognate sciences. For this purpose, additions are being made constantly to the number of species cultivated in the grounds and plant houses, and to the library and herbarium, and, as rapidly as it can be utilized, it is proposed to secure apparatus for work in vegetable physiology, etc., the policy being to secure a good general equipment in all lines of pure and applied botany, and to make

this equipment as complete as possible for any special subject on which original work is undertaken by competent students.

A very large number of species, both native and exotic, and of horticulturists' varieties, are cultivated in the Garden and Arboretum and the adjoining park, and the native flora easily accessible from St. Louis is large and varied. The herbarium, which includes nearly 250,000 specimens, is fairly representative of the vegetable life of Europe and the United States, and also contains a great many specimens from less accessible regions. It is especially rich in material illustrative of Cuscuta, Quercus, Coniferae, Vitis, Juncus, Agave, Yucca, Sagittaria, Epilobium, Rumex, Rhamnaceae, and other groups monographed by the late Dr. Engelmann or by attachés of the Garden. The herbarium is supplemented by a large collection of woods, including veneer transparencies and slides for the microscope. The library, containing about 8,000 volumes and 10,000 pamphlets, includes most of the standard periodicals and proceedings of learned bodies, a good collection of morphological and physiological works, nearly 500 carefully selected botanical volumes published before the period of Linnaeus, an unusually large number of monographs of groups of cryptogams and flowering plants, and the entire manuscript notes and sketches representing the painstaking work of Engelmann.

The great variety of living plants represented in the Garden, and the large herbarium, including the collections of Bernhardi and Engelmann, render the Garden facilities exceptionally good for research in systematic botany, in which direction the library also is especially strong. The living collections and library likewise afford unusual opportunity for morphological, anatomical and physiological studies, while the plant house facilities for experimental work are steadily increasing. The E. Lewis Sturtevant Prelinnean library, in connection with the opportunity afforded for the cultivation of vegetables and other useful plants, is favorable also for the study of cultivated plants and the modifications they have undergone.

These facilities are freely placed at the disposal of professors of botany and other persons competent to carry on research work of value in botany or horticulture, subject only to such simple restrictions as are necessary to protect the property of the Garden from injury or loss. Persons who wish to make use of them are invited to correspond with the undersigned, outlining with as much detail as possible the work they desire to do at the Garden, and giving timely notice so that provision may be made for the study of special subjects. Those who have not published the results of original work are requested to state their preparation for the investigation they propose to undertake.

Under the rules of Washington University, persons entitled to candidacy in that institution for the Master's or Doctor's degree may elect botanical research work as a principal study for such degrees, if they can devote the requisite time to resident study.

William Trelease,
Director

The annual events provided for in Mr. Shaw's will have taken place as follows: the preaching of a sermon on the wisdom and goodness of God as shown in the growth of flowers, fruits, and other productions of the vegetable kingdom; the sixth banquet to the Trustees of the Garden and their invited guests; the sixth banquet to the gardeners of the institution and invited florists, nurserymen and market gardeners; and the award of premiums or prizes at a flower show or exhibition held in St. Louis.

The flower sermon was preached in Christ Church Cathedral, St. Louis, on the morning of May 19th, by Rt. Rev. W. C. Doane, Bishop of Albany.

The Trustees' banquet was given at the Planters' House, on the evening of May 17th, and was presided over by Chancellor W. S. Chaplin, of Washington University, 92 gentlemen representative of St. Louis or distinguished as teachers or investigators in various parts of the country being present.

Speeches appropriate to the occasion were made by President Henry Wade Rogers, of Northwestern University, whose address is elsewhere printed in the Seventh Report, by direction of the Board; Hon. Smith P. Galt, of St. Louis; Professor W. O. Atwater, of Wesleyan University; and Rev. Dr. J. W. Lee, of St. Louis.

On the evening of the 14th of September, the sixth annual banquet to the gardeners of the institution, and invited florists, nurserymen, and market gardeners of St. Louis and vicinity, was given at the University Club, St. Louis. Covers were laid for one hundred persons, comprising the gardeners and office staff of the Missouri Botanical Garden, several members of the Board of Trustees, a large number of commercial florists and market gardeners of the vicinity, a number of amateurs interested in gardening and home improvement, and representatives of the horticultural press and the horticultural societies of Missouri and adjacent States. The Director of the Garden presided, assisted by Professor J. C. Whitten, of the Univer-

sity of Missouri, who officiated as toastmaster. Short and appropriate speeches were made by Jonathan Periam, for many years editor of the *Prairie Farmer;* L. A. Goodman, Secretary of the Missouri Horticultural Society; D. I. Bushnell, ex-President of the American Seed Trade Association; H. C. Irish, Horticultural Assistant at the Garden; Dr. A. A. Kleinschmidt, President of the Cactus Association of St. Louis, and J. G. Smith, in charge of the recently established grass garden of the United States Department of Argiculture.

The awarding of flower premiums for 1895 was again intrusted to the Florists' Club of St. Louis, for the benefit of a chrysanthemum exhibition held in the Exposition building, St. Louis, in November. In general, premiums were offered and awards made for plants and flowers of the general character of those in competition in previous years. Although one consignment of a considerable number of species was entered for the Shaw Medal,* the judges again declined to make an award of this medal, on the ground that so far as the plants themselves showed, there was no evidence of superior decorative or economic importance for the United States that would justify the award, — a decision that I hope will encourage the introducers of plants of unquestionable merit to exhibit them in competition for this medal.

Under the authority given by the Board in 1894, to admit a limited number of garden pupils in addition to those holding scholarships,† one such pupil was received in the spring, and in accordance with the announcement issued in the preceding autumn, the one disposable scholarship was awarded in March, to Walter Nehrling, of Wisconsin, on the result of competitive examinations. Mr. J. P. Pillsbury, who relinquished his scholarship last winter, having completed the requisite work subsequently, was

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* Fifth Report, 18; Sixth Report, 20.

† Sixth Report, 21.

CHYSIS BRACTESCENS.

admitted to examination in October, and awarded the certificate due on completion of the four years' course.

Three more pupils will have completed the course in March, 1896, and in November last an announcement, similar to those of previous years, was issued, stating that two of the vacancies will be filled in the spring on the result of competitive examination, the third being reserved for a qualified nominee of the St. Louis Florists' Club, in accordance with the action of the Board in establishing free scholarships.*

THE SCHOOL OF BOTANY.

During the college year 1894–5 I was assisted by Mr. C. H. Thompson as general Instructor, and Mr. O. L. Simmons as Instructor in cryptogamic botany, Mr. Thompson's place being filled for the year 1895–6 by the appointment of Mr. W. H. Rush as general Instructor. Undergraduate classes were conducted in elementary morphology and organography (1)†, elementary anatomy and phanerogamic botany (2), synoptical work with cryptogams (3), economic mycology (10–11), garden botany (12–13), and vegetable physiology (14). In the spring, a course of ten lectures on the structure and physiology of plants, by myself, and several courses in phanerogamic botany and pteridophytes, by Miss A. I. Mulford, were given to special students, at the Garden. In the autumn and winter Miss Mulford has continued her excellent work with special classes by giving at the Garden and in the public school buildings a number of teachers' courses, adapted to the science requirements of the public schools, a direction in which I am especially desirous of having the Garden facilities utilized to the utmost.

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* First Report, 95.

† The numbers in parenthesis refer to the numbers by which the courses are designated in the last catalogue of Washington University, and the Sixth Garden Report, pp. 24–5.

Through the college year, Miss Mulford was occupied at the Garden with a study of the United States representatives of the genus Agave, on which she presented a thesis for the Doctor's degree, which she received from Washington University at its last commencement.

Since the opening of the present college year, one candidate for the Master's degree has been devoting two mornings a week to a study, at the Garden, of trees and shrubs in their winter condition, under my instruction, in addition to taking several of the undergraduate electives in botany at the University.

Very respectfully,

WM. TRELEASE,
Director.

SCIENTIFIC PAPERS.

JUGLANDACEAE OF THE UNITED STATES.

BY WILLIAM TRELEASE.

In 1893–4, a study of the North American Juglandaceae was made, which led to the preparation of a synoptical revision of the species occurring in the United States, but as several supposed hybrids had been received in fruit, which it was desirable to have represented by material showing flowers and foliage, the manuscript was laid aside for a year and again taken up in the fall of 1894. At that time, however, more fruiting material requiring additional summer collections was received, so that the revision, as then completed, was again laid aside. In February, 1895, the seventh volume of Professor Sargent's Silva of North America appeared, so that it is not now considered desirable to publish the entire manuscript I had prepared. The following pages, therefore, contain merely such a tabulation of the fruit, twig, bark and bud characters as it is thought will be helpful in field studies, with notes on the hybrid forms referred to.

In a memoir published in 1862,* as well as in a descriptive monograph of the Juglandaceae,† M. De Candolle makes use of certain characters derivable from the winter buds, by which not only the large groups but even some species of hickory may be distinguished; and, in fact, most of the species are more readily known in their winter condition than during the period of flowering or the early summer season. This is also true of the walnuts, where differences

* Annales des Sciences naturelles, Bot., ser. 4, xviii. 1.

† DC. Prodromus, xvi. (2), 142, 144.

in the pith are added to those observable in the buds and bark.*

Professor Britton, in an article published in 1888, restoring the Rafinesquian name Hicoria for the genus which had so long been known as Carya,† bases a primary subdivision of the genus upon the location of the staminate catkins, this grouping being somewhat different from that of De Candolle. It seems to me, however, that the bud, fruit, and inflorescence characters are complementary to one another, the lateral umbels of the Pecan, which were held by Britton to be peculiar, resulting merely from the abortion of many of the shoots on which they are basal, and I am glad to see that Professor Sargent, in his recent treatment of the genus, has come to substantially the same conclusion. In the following pages, therefore, Britton's subgenus Pacania has been amplified so as to include all of the species comprised in the section Apocarya as understood by De Candolle.‡ This being done, Eucarya of De Candolle and Engler, and Euhicoria of Britton, have an identical limitation. In the main I quite agree with Professor Sargent § in the limitation of species, and the nomenclature of the Silva is followed unless the contrary is specifically stated, so that this paper is not incumbered with the detailed synonymy of each species, which can easily be ascertained by reference to the Silva.

During the past year Nawaschin ‖ has ascertained that the pollen tube of Juglans regia reaches the embryo sac by growing through the walls of the ovary and the chalaza instead of passing through the cavity of the ovary and the micropyle, a phenomenon previously discovered in Casuarineae, Myricaceae, Betulaceae, etc., and supposed to

* See Beal, American Naturalist, xv. 32.

† Bulletin of the Torrey Bot. Club, xv. 277.

‡ See also Engler & Prantl, Pflanzenfamilien, iii. (1), 25.

§ Sargent, Silva of North America, vii. 132, 134.

‖ Bot. Centralblatt, lxiii. 353–7; Smith, Am. Nat. xxix. 1103; Goodale, Am. Journ. Sci. 3 ser. l. 429.

indicate a transition from the Gymnosperms to the Angiosperms, and, by implication, great antiquity for the groups of the latter in which it occurs.

In their pollination, the Juglandaceae are strictly anemophilous.* While the staminate and pistillate flowers of a given tree generally develop simultaneously in *Hicoria*,† Pringle ‡ has observed a tendency to a separate development of the two sorts of flowers, and Meehan § states that in some cases a number of warm days in winter suffice to cause the staminate catkins to develop long in advance of the pistillate flowers. In *Juglans regia*, Kirchner ‖ has noticed that the staminate and pistillate flowers of a given tree develop together, but Meehan ¶ has observed protandry of a month or more on certain walnut trees, after a winter with mild days, and De Candolle ** also makes record of protandry in this genus. In 1875, Delpino †† called attention to the curious circumstance that certain trees of the European walnut are protandrous while others are protogynous, a fact commented on by Darwin ‡‡ and verified for the American *J. cinerea* by Pringle,§§ in 1879, the staminate flowers of one lot of trees blooming simultaneously with the pistillate flowers of others, the other sex of both lots also developing synchronously some ten days later. Kerner ‖‖ states that the staminate flowers open explosively.

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* H. Mueller, Bienen Zeitung, 1882, 23; Engler & Prantl, Pflanzenfamilien, iii. (1), 21.

† De Candolle, Ann. Sc. nat. 4 ser. xviii. 12. On the presumable power of self-fertilization in the Pecan, see Meehan, Bot. Gaz. v. 11.

‡ Bot. Gazette, iv. 237.

§ Proc. Phila. Acad. 1885, 117.

‖ Neue Beobachtungen über die Bestäubungseinrichtungen einheimischen Pflanzen, Stuttgart, 1886, 13.

¶ *l. c.* 117.

** *l. c.* p. 12.

†† Nuovo Giorn. Bot. Ital., vii. 148; Ulteriori Osservazioni, ii. (2), 337.

‡‡ Different Forms of Flowers, 10.

§§ Bot. Gazette, iv. 237.

‖‖ Verhandl. Zool.-bot. Gesellsch., Wien, 1887, xxxviii. p. 28.

The principal literature of the wood, twig and bud differences of the genera *Hicoria* and *Juglans* is indicated in the following list. A generic key, based on wood structure, is given by Solereder, Holzstructur, 246, and one based on bark characters is given by Moeller, Anat. Baumrinden, 308, while a bud synopsis is given by De Candolle, in the memoir cited, p. 8.

HICORIA.

General.

Winter Characters.

Brendel, Tree in Winter (Bull. Ill. Lab. Nat. Hist. i.), 28, 30, pl. 4, f. 18. — Damaskinos and Bourgeois, Bull. Soc. Bot. de France, v. 610. — Diez, Flora, 1887, 550. — Feist, Schutzeinrichtungen der Laubknospen, 327–8. — Foerste, Bot. Gaz. 1892, 182–3.

Histological Characters.

Hartig, Anat. Unterscheidungsmerkmale Hölzer, 9; 3d ed. 18; Engl. transl. by Somerville, 33; Bot. Zeitung, 1859, 106.— Houlbert, Ann. Sci. Nat., Bot. 7 ser. xvii. 161. — Mayr, Waldungen N. Amer. 153. — Solereder, Holzstructur, 244.

H. alba.

Winter Characters.

Brendel, *l. c.* pl. 2, f. 20. — De Candolle, Mémoire Juglandées, 7–8.— Foerste, Bull. Dennison Univy. i. 30.— Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 162.— Hough, Amer. Woods, iv. 90 (3 sects. wood).—Moeller, Beitr. z. Vergl. Anat. des Holzes, 95.

H. aquatica.

Winter Characters.

De Candolle, *l. c.* 7–8, f. 4.

Histological Characters.

Houlbert, *l. c.* 161. — Hough, Amer. Woods, v. 115 (3 sects. wood).

H. glabra.

Winter Characters.

De Candolle, *l. c.* 7–8, f. 5–6.—Feist, *l. c.* 336.—Foerste, Bull. Dennison Univy. i. 30.—Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 163.—Rothrock, Good and Bad Timber, f. *c–d*.

H. glabra, microcarpa.

Winter Characters.

Bailey, Amer. Gard. xi. 381, 385–8.—Foerste, Bull. Dennison Univy. i. 30.

Histological Characters.

Hough, Amer. Woods, iv. 91 (3 sects. wood).

H. laciniosa.

Winter Characters.

De Candolle, *l. c.* 7, 8.—Foerste, Bull. Denn. Univ. i. 30.—Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 162.

H. minima.

Winter Characters.

Brendel, *l. c.* pl. 2, f. 22.—De Candolle, *l. c.* 7–8.—Feist, *l. c.* 328.—Foerste, Bull. Denn. Univ. i. 30.—Hitchcock, Key to Kas. Trees, 6, f. 16–17; Opening of Buds, 138, f. 102–3; Plants of Manhattan, 18.

Histological Characters.

Gnetzsch, Radiale Verbindungen der Gefässe. Dissert. 1888, 19.—Gris, Moelle des Plantes Ligneuses, 279; Extr. Moelle Pl. Lign. 31, pl. 6, f. 7, 7, f. 10.—Hough, Amer. Woods, ii. 37 (3 sects. wood).—Kny, Abnormität in d. Abgrenzung der Jahresringe, 4.—Moeller, Anat. Baumrinden, 312, with figure.

H. ovata.

Winter Characters.

Bailey, Amer. Gard. xi. 386-7.— Brendel, *l. c.* 29, 30, pl. 2, f. 19, pl. 4, f. 17.—De Candolle, *l. c.* 7.— Döll, Laubknospen Amentaceen, 21, f. 18.—Foerste, Bull. Denn. Univ. i. 30, f. 2.— Hitchcock, Key to Kas. Trees, 6, f. 18; Pl. Manhattan, 18.— Rothrock, Forest Leaves, iv. 56, figures.

Histological Characters.

Brooks, Wood Sections, 15 (radial and tang. sects. wood.—The cross section is *Fagus*).— Hough, Amer. Woods, ii. 36 (3 sects. wood).— Houlbert, *l. c.* 162.— Mayr, Waldungen N. A. 158, figs.— Moeller, Anat. Baumrinden, 311, fig.— Moeller, Vergl. Anat. Holz. 95, f. 67.—Wiesner, Rohstoffe, 615, f. 79.

H. Pecan.

Winter Characters.

Brendel, *l. c.* 31, pl. 2, f. 21.— De Candolle, *l. c.* 7–8, f. 3.— Foerste, Bull. Denn. Univ. i. 30, f. 3.— Hitchcock, Key to Kas. Trees, 6.

Histological Characters.

Houlbert, *l. c.* 162.

JUGLANS.

General.

Winter Characters.

Beal, Amer. Nat. xv. 32.— Bösemann, Deutschland's Gehölze im Winterkleide, 60.— Brendel, *l. c.* 28.— Damaskinos & Bourgeois, *l. c.* 610.— De Candolle, *l. c.* 7–8.— Foerste, Bot. Gaz. 1892, 182–3, fig. 20.— Wilkomm, Laubhölzer im Winter, 6.

Histological Characters.

Brendel, *l. c.* 31.— Flot, Ann. Sc. Nat. 7 ser. xviii. 72.— Foerste, Bot. Gaz. 1892, 186.— Gris, Ext. Moelle Pl.

Lign. 42.— Hartig, Bot. Zeit. 1859, 106.— Houlbert, *l. c.* 156, 159, 163, 176.— Lecomte, Ann. Sc. nat. 7 ser. x. 218.— Mueller, Rinde Laubholz. 7.— Solereder, Holzstructur, 245.

J. cinerea.

Winter Characters.

Beal, Amer. Naturalist, 1881. 36, fig.— Bösemann, *l. c.* 60.— Brendel, *l. c.* pl. 2, f. 17.— Powell, Amer. Gard. xiii. 708, fig.

Histological Characters.

Gnetzsch, *l. c.* 19.— Gris, Moelle Pl. Lign. 278; Extr. Moelle Pl. Lign. 21, pl. 6, f. 5.— Hough, Amer. Woods, i. 14 (3 wood sections).—Houlbert, *l. c.* 159.—Dawson, Amer. Journ. Pharm. xlvi. 167.

J. nigra.

Winter Characters.

Beal, *l. c.* 36, fig.— Brendel, *l. c.* pl. 2, f. 18.—Döll, *l. c.* 21.— Feist, *l. c.* 327.— Hitchcock, Pl. Manhattan, 17; Key to Kas. Trees, 4, f. 13; Opening of Buds, 138, f. 99–101.— Rothrock, Forest Leaves, iv. 38–40, fig.— Schwarz, Forstl. Flora, 431.

Histological Characters.

Brooks, Wood Sects. 9 (3 wood sections).— Gerber, Jährl. Korkproduction, 27.— Gnetzsch, *l. c.* 19. — Hartig, Unterscheidungsmerkmale, 2 ed. 28; Engl. transl. 51. — Hough, Amer. Woods, ii. 35 (3 sects.).— Houlbert, *l. c.* 160.— Koeppen, Verhältn. d. Rinde uns. Laubbäume, pl. 21, f. 8, 16*a*.— Moeller, Anat. Baumrinden, 309, fig.— Nördlinger, Anat. Merkmale Wald- u. Gartenholzarten, 11.— Potonié, Sitzber. Bot. Ver. Prov. Brandenb. xxii. 81. — Tolman, Amer. Monthly Micr. J. xi. 55, f. 9.— Troschel, Mestom im Holze der dikot. Laubbäume. Diss. 1879, 19.

WINTER SYNOPSIS.

Hicoria, Raf. *Carya*, Nutt.

Pith not chambered (but sometimes cracking across at intervals when dry); buds frequently superposed, subnaked to evidently scaly, the lateral sometimes inclosed in a sac soon splitting at top, and often stalked; vernation of leaflets involute-convolute (pl. 23, f. 1); catkins not elongating until spring; fruit with the husk parted at least near the top, and usually deciduous.

* Bud scales 4 to 6, valvate in pairs, often with apical lobes and in some species more or less enlarging into leaves in spring, conspicuously yellow dotted (except sometimes in the first); larger lateral buds often long stalked; staminate catkins from lateral buds of the preceding year as well as at base of the new growth.— § *Pacania* or *Apocarya*.

+ Outer bud scales more or less fused, loosening at base; terminal buds elongated except in the second.

++ Nut mostly elongated, subterete; the husk dehiscent nearly or quite to the base, its lobes usually with a raised margin.

1. H. Pecan (Marshall) Britton. *Carya olivaeformis*, Nuttall.— The Pecan.— A large tree; bark thick, buff gray, deeply fissured but not shaggy; twigs gray, with a shade of buff, dull, from tomentose-hirsute becoming nearly glabrous, the minute pale lenticels mostly inconspicuous the first year; buds elongated, gray, the terminal appressed, pubescent and yellow-glandular, the lateral soon nearly or quite glabrous; fruit 1 to 2 in. long; husk 2 to 3 mm. thick, splitting to the base, often persistent on the tree after the nut falls; nut ovoid to ellipsoid, more or less pointed at the ends, brown, irregularly flecked and striped with a darker color, 2-celled; shell firm, scarcely 1 mm. thick, the commissure weak and brown-spongy in the center; kernel sweet, little ruminated. — Iowa to southern Indiana, Kentucky, Louisiana and Texas, extending into Mexico,— in river bottoms.— Pl. 1, 2, 13, f. 1–3, 16, f. 7–11.

The fruit of the Pecan is one of the most variable nuts, some specimens being narrowly oblong while others are almost as broad as long. At the base, the commissure usually bears a delicate wing at each side, — an approach to the 4-celled base of other hickory nuts. The deeper color and conspicuous gloss of nuts from certain sections as they appear in the market does not indicate any botanical difference, but is the result of treatment which they undergo before being offered for sale.

In 1894, Mr. S. J. Galloway reported sweet-fruited nuts obtained from a single tree near Eaton, Ohio, which he believed to be a hybrid of the Pecan with some other species.* Of this tree, which appeared spontaneously some twenty-five yards from a cultivated Pecan, Mr. Galloway has been kind enough to send me ample flowering and fruiting specimens and twigs, which show that it resembles the Pecan in foliage and in the general form of the fruit and the character of the kernel, while it differs in having the staminate catkins stalked, as in other hickories, and in the nut, which, while elongated, is somewhat flattened, broader upwards, slightly marked by low-rounded prominences as in *H. minima*, acuminately pointed, only a little dark mottled, and evidently 4-celled for about 6 mm. from the bottom of the cavity. The twigs are slenderer than is usual in the Pecan, and nearly glabrous, and the slender buds are all conspicuously yellow dotted.—Pl. 16, f. 12–14, 20.

Mr. F. Reppert, of Muscatine, Iowa, has also placed in my hands specimens from several trees found near that city, which in aspect resemble the Bitternut, and in twig and bud characters approach the Galloway tree. The nuts, also, in shape and striping are more or less like the broader forms of Pecan nuts, though they are thinner shelled and 4-celled to a greater height, while the kernel is somewhat astringent.— Pl. 16, f. 15–16.

On the whole, the characters of these trees are inter-

* Gardening, Apr. 1, 1894, 226; Sargent, Silva, vii. 138.

mediate between the Pecan and Bitternut (*H. minima*), and they seem clearly to be hybrids of those species. The husk in most cases is intermediate in thickness between the two assumed parents. *Hickorea Texana,* Leconte* seems to be a similar hybrid, and the figure published by Leconte in his article represents quite well some of the nuts referred to above. Dr. Mohr † has reported the Pecan as hybridizing with the Water Hickory, but I have seen no specimens indicating this hybrid. The Pecan further hybridizes in an interesting way with the Mocker Nut and the Bottom Shellbark, under which species the hybrids are considered.

2. H. MYRISTICAEFORMIS (Michx. f.) Britton. *Carya myristicaeformis,* Nuttall.— The Nutmeg Hickory.— A medium sized tree; bark thin, dark brown-gray, falling in small scales or more shaggy and in netted flakes; twigs gray buff, dull, not hairy but at first densely covered with golden brown glistening peltate glands, the lenticels inconspicuous; buds ovoid, densely brown scurfy, the tomentose inner scales of the terminal soon exposed; fruit about 1 in. long, ellipsoidal; husk 1 to 2 mm. thick, splitting nearly to the base; nut ellipsoidal, mucronate at both ends, brown or gray, conspicuously dark striped, 4-celled below; shell very hard, 1 to 2 mm. thick, the commissure firm but dark lined; kernel sweet, not ruminated.— Arkansas to Alabama, Texas and Mexico, and in South Carolina,— in wet bottoms, occasionally extending into ravines and uplands; generally local.— Pl. 13, f. 7–9, 17, f. 1–4.

++ ++ Nut usually as broad as long, very thin shelled, flattened, 4-celled below.

3. H. AQUATICA (Michx. f.) Britton. *Carya aquatica,* Nuttall.— The Water Hickory.— A rather small tree, becoming large in Arkansas; bark thin, light gray, shaggy

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* Proc. Philadelphia Acad. 1853, 402.

† Garden and Forest, 1889, 570.

exfoliating; twigs gray to very dark reddish-brown, then seeming almost black, often glossy, soon glabrous and at length nearly glandless, the few small white lenticels very evident; buds less stalked and rather shorter than is usual in the group, nearly black, evanescently yellow glandular, the terminal at first also sparingly hairy; fruit 1 to 2 inches long; husk 1 mm. thick, splitting to the base; nut very much flattened, umbonate to retuse at top, variously erosely ridged and angled, dull reddish-brown; shell soft, about .5 mm. thick, with large lacunae filled with a dark red spongy tissue, the commissure soft; kernel very bitter, much ruminated.— Virginia to Florida, around the Gulf to Texas, thence north to Arkansas and southern Illinois,— in wet bottoms, on gravelly river banks, etc.— Pl. 3, 4, 13, f. 4–6, 16, f. 1–3.

++ Scales of terminal buds free above, all but the outermost developing into leaves; nut usually as broad as long, elliptical in cross section, 4-celled below.

4. H. MINIMA (Marshall) Britton.— *Carya amara*, Nuttall.— The Bitternut.— A medium sized to rather large tree; bark thin, light gray, with shallow fissures and separating somewhat in small thin flakes; twigs buff, exceptionally gray or reddish, rather dull, glabrous or slightly hairy at the end but usually very yellow glandular above, the numerous small pale lenticels evident; buds closely yellow dotted and somewhat pubescent between the scales, those superposed above the leaf scars often considerably separated and the uppermost of each series usually long stalked or lengthening into a twig the first season; fruit from less than an inch to an inch and a half long, obovoid to subglobose; husk 1 mm. thick, irregularly splitting to a little below the middle; nut sometimes broader than long, rounded at base, depressed and mucronate at top, slightly marked with rounded prominences conformed to the kernel, gray to buff, without darker stripes; shell very soft, .5 mm. thick, the commissure soft; kernel very bitter, ruminated.— Canada and Maine to Minnesota and

Nebraska, south to Texas and Florida,— in various situations.— Pl. 5, 6, 13, f. 10–12, 16, f. 4–6.

Apparently the Bitternut hybridizes with the Pecan, the hybrids more or less closely approaching the former in twig and foliage characters and in the thinness of shell and the form of the nut, while they more nearly resemble the latter in the striping and nearly 2-celled structure of the nut, which, while less bitter than in true *minima*, is usually decidedly astringent.

* * Buds always truly scaly, their scales 10 or more, imbricated or the outermost on lateral buds usually a closed sac soon splitting from the top, the inner hairy; staminate catkins at the base of the new growth only, each group of three on an exserted common peduncle; nuts (except in forms referred to under *ovata* and *laciniosa*) firm shelled, 4-celled at base; kernel not ruminated.— § *Euhicoria* or *Eucarya.*

+ Buds small (5 to 10 mm. long), becoming subglobose toward spring, their outer scales commonly glandular dotted; twigs glabrate, cherry colored to gray, slender for the group.

5. H. GLABRA (Miller) Britton. *Carya porcina*, Nuttall.— The Pignut.— A medium sized tree; bark thick, dark gray, checked much like that of the mature white ash; twigs purplish to dull gray, often without conspicuous lenticels; buds reddish brown to gray, silky after parting the outer scale; fruit about an inch long, pyriform, mostly apophysate, elliptical in cross section; husk about 1 mm. thick, rarely splitting far, and never below the middle; nut ellipsoidal, not angled, pointed from the mostly sunken apex, usually mucronate at the base, dirty brown; shell about 2 mm. thick, the commissure stout; kernel of inferior quality. Two forms of fruit occur, the longer marking the variety *ficiformis*, and the shorter the variety *obcordata*, but these appear scarcely worthy of varietal separation.— So far as my specimens show, limited to the Atlantic region, from Massachusetts and Pennsylvania to Florida.— Pl. 7, 14, f. 1, 17, f. 5–6.

Var. ODORATA (Marshall) Sargent.— Bark rough fissured, as in the Mockernut, or sometimes resembling the

white elm, but not shaggy; twigs often nearly red; fruit ellipsoidal to subglobose, rarely apophysate, the evident articulation close to its base; husk splitting almost to the base, often at first with raised lines along the sutures; nut gray or brownish, somewhat angled.— From the Mississippi Valley eastward, and from Canada to the Gulf, — mostly in uplands.— Pl. 8, 14, f. 3–5, 17, f. 9–14.

Var. VILLOSA, Sargent.— Bark deeply fissured and very rough, but not at all shaggy; twigs very slender, red, mostly tomentose; fruit about as in the preceding variety; nut mostly very brown, thick shelled and strongly angled, resembling the Mockernut.— Missouri, on flinty hills.— Pl. 9, 14, f. 6, 18, f. 1–2.

Var. MICROCARPA (Nuttall) Sargent. — Bark more or less shaggy, often as rough as in the Shagbark; fruit subglobose; husk often glossy, splitting nearly to the base; nut mostly gray or whitish, angled, rather thin shelled for the group, the kernel sweet. — Same range as the variety *odorata*.— Pl. 10, 14, f. 2, 17, f. 7–8.

Of all of the hickories, this is the most variable, as it is now understood, and I am far from satisfied with any arrangement of its forms that has yet appeared. In the character of the bark, form and dehiscence of fruit, and size, shape, color, hardness and degree of angling of the nut, differences are met with that would generally furnish specific or at least varietal characters, and to a certain extent this is true of the number of the leaflets; yet these differences, which individually are marked, occur so variously combined that little dependence can be placed on them separately. It seems evident, however, that the typical eastern Pignut, with nearly indehiscent husk, does not occur west of the Alleghenies, being replaced in the west by the dehiscent fruited form that I have designated as variety *odorata*, which so insensibly merges into *microcarpa* as to make any separation of these two purely arbitrary, unless the shaggy bark of the latter furnishes a character always to be trusted by association with the whiter, thinner shelled nuts

which are observable in much of the form named *micro-carpa*.

As a rule the prevalent number of leaflets in both of these forms seems to be 5, while their number is rarely more than 3 in the eastern Pignut, with which, as will be seen, the other two forms are likely to be associated east of the Alleghenies. The hairy hill form, called *villosa*, not infrequently bears nuts which, separated from husk and twig, might easily pass for extreme forms of the Mockernut, and I was for a time inclined to consider this variety a hybrid with the latter, but this opinion does not appear to be substantiated by a fuller knowledge of the facts. In the southern Appalachian region are also found trees with leaves persistently tomentose until the maturity of the fruit, which are deserving of further study.

+ + Buds large (the terminal 8 to 15 mm. long), ovoid, nearly or quite glandless; twigs frequently somewhat tomentose at end, buff, gray or brownish, usually much stouter.

++ Bark not shaggy; outer scales of terminal buds soon deciduous; husk of medium thickness, not parted quite to the base; nut angular but not much broader than thick.

7. H. ALBA (L.) Britton. *Carya tomentosa*, Nuttall.— The Mockernut.— A medium sized tree; bark gray, rather thin, deeply fissured and also checked into minute scales; twigs rather stout, mostly reddish-gray and with conspicuous lenticels, often tomentose; terminal buds densely hairy, broadly ovoid, obtuse to very acute, the outermost scales falling in early autumn, exposing the yellowish-gray silky inner scales, some of which fall during the winter; lateral buds red-brown, the outer scale often splitting only late; fruit one and a half to two and a half inches long, depressed globose to pyriform; husk 3 to 4 mm. thick, splitting to some distance below the middle; nut brown, from globose to narrowly ovoid-oblong, mostly somewhat flattened and (often obscurely) angled, usually acute at both ends and in the longer forms attenuate above; shell about 2 mm. thick and very hard, the commissure firm;

kernel of fair flavor, but frequently abortive and replaced by a spongy mass.— Canada to the Great Lakes and Kansas, south to Texas and Florida, — in uplands. — Pl. 11, 14, f. 7–9, 15, f. 1–3, 18, f. 3–10.

Occasional nuts, clearly of this species, occur with husks parted to the base and 7 to 12 mm. thick, suggesting hybridity with *ovata*, but I have not been able to study the trees from which they came. Other fruits suggest possible hybridity with the preceding species.

In the autumn of 1894, Dr. J. Schneck, of Mt. Carmel, Ill., and Mr. F. Reppert, of Muscatine, Iowa, sent to the herbarium twigs and fruit of bottom land trees that appear to be hybrids of this species with the Pecan.* The bark of the Iowa tree is described as being much like that of the Mockernut, while the tree of Dr. Schneck is smooth-barked, resembling the Pecan. So far as I have seen them the twigs of both might pass for those of *alba* except that the outer scales of the terminal buds are persistent, while the foliage, though intermediate, is strongly suggestive of that of the Pecan. The fruit is oblong, almost 2 in. long, the husk 6 mm. thick, parted nearly to the base, with strongly elevated margins to the segments, and rather persistent on the tree. The nuts are nearly as pale as in the Shagbark, conspicuously brown striped, slightly 4-celled at the very base, and with a wall only 1 mm. thick. As is usual in *alba*, they are upwardly attenuate, and frequently the kernel is abortive. It is not impossible that these hybrids represent the *Juglans rubra* of Lamarck (Illustr. iii. 365, pl. 781, f. 4) and of Gaertner (Fr. pl. 89).— Pl. 21, 23, f. 2–5.

++ ++ Bark shaggy; outer bud scales persisting through the winter; nut angular and flattened from the side.

= Fruit broader than long; husk moderately thick, not parted to the base.

8. H. Mexicana (Engelm.) Britton. *Carya Mexicana*, Engelmann.— A medium sized tree; bark "apparently

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* On one of these see Sargent, Silva, vii. 138.

scaly; " twigs gray-brown, dull, glabrous, with numerous small but very evident pale lenticels; " buds ovate acute, about one-fourth inch long, with pubescent scales, the outer acuminate, often with subulate points; " fruit about an inch long, depressed; husk 6 mm. thick, splitting to below the middle; nut broader than high, mucronate at both ends, the apex truncate or depressed; shell nearly white and of a chalky appearance, sharply angled, nearly 2 mm. thick, with very thick commissure; kernel? — Mexico, known only from Palmer, 835½, from the high mountains of Alvarez, twenty miles southeast of San Luis Potosi, at an altitude of 8,000 ft.— The only species not native to the United States.— Pl. 19, f. 1–3.

In its husk characters and pubescence, this is most closely related to *H. alba*, but the bark (if really shaggy), bud, leaf and nut characters, bring it close to *H. ovata*.

= = Fruit subglobose or ellipsoidal; husk very thick, completely separating into 4 pieces; nut rather thin shelled, the kernel large and sweet.— In this group many of the petioles remain adherent to the twigs during the winter.

9. H. LACINIOSA (Michx.) Sargent. *Carya sulcata*, Nuttall.— The Bottom Shellbark.— A large tree; bark thick, light gray, coarsely flaking in very large scales with deep open sinuses, but usually less shaggy than in the next; twigs stout, buff or often nearly orange, mostly a little velvety or tomentose, with usually rather inconspicuous lenticels; terminal bud stout, with tomentose keeled outer scales; fruit ellipsoidal, two to two and a half inches long; husk about 10 mm. thick, finely velvety pubescent; nut longer than broad, mucronate at both ends, yellow; shell about 2 mm. thick, the commissure firm; kernel sweet.— New York and Pennsylvania to Iowa, Kansas, and the Indian Territory, — exclusively in river bottoms.— Pl. 15, f. 4–5, 19, f. 4–5.

In the American Agriculturist for 1884, p. 546, f. 1, Mr. A. S. Fuller published an account of a supposed hybrid between this species and the Pecan, which has been called the

Nussbaumer hybrid, after Mr. J. J. Nussbaumer, of Okawville, Ill., who first brought it to the attention of Judge Samuel Miller, of Bluffton, Mo. Mr. Nussbaumer writes me that the original tree, which stands in the bottom between Mascoutah and Fayetteville, Ill., in general appearance resembles *laciniosa*, though the bark is intermediate between that of the Pecan and Mockernut. Professor Sargent states (Silva, vii. 158) that a small tree grown from this in New Jersey by Mr. Fuller, cannot be distinguished from *laciniosa* of the same age; and I should hardly be able to distinguish an imperfect twig from a small tree, cultivated by Judge Miller, from *laciniosa*. The nut, however, is very peculiar, being more elongated than is usual in that species, and widened upwardly, less acutely angled "as if the ridges had been sandpapered down," and so thin shelled that it can be crushed easily by pressing two together in the palm of the hand. A somewhat similar nut, originally from Indiana, was described by Mr. Fuller in the New York Weekly Tribune, July 9, 1892 (Sargent's Silva, *l. c.*) as cultivated by Mr. R. M. Floyd, of Cedar Rapids, Iowa. And in the autumn of 1895, Dr. J. Schneck sent me ample fruit, twig and leaf specimens of a similar hickory from Posey County, Indiana. The nut of this last is almost identical with a specimen of the Nussbaumer nut in the Engelmann herbarium, while its twigs closely resemble those of *laciniosa*, and the leaves are decidedly of the Pecan type. I am led to the conclusion, therefore, that these several forms really represent hybrids between *H. Pecan* and *H. laciniosa*. In size, quality, and thinness of shell, they appear to be the most valuable of American nuts.—Pl. 22, 23, f. 6–9.

10. H. OVATA (Miller) Britton. *Carya alba*, Nuttall.—The Shagbark or Shellbark.—A large tree; bark loosely flaking in large scales, the base of old trees merely checked; twigs slenderer, gray often tinged with red, only

exceptionally slightly tomentose, with numerous elongated white lenticels; buds somewhat smaller and with the nearly glabrous outer scales commonly longer pointed; fruit subglobose, about an inch and a half long; husk 5 to 8 mm. thick, glabrous; nut nearly one-half smaller than in the last, typically scarcely longer than broad, nearly white; shell 1 mm., the firm commissure very thin; kernel very sweet.— Canada to Minnesota, south to Florida, Kansas, and Texas,— in river bottoms and uplands.— Pl. 12, 15, f. 6–9, 19, f. 6–7.

Like the Pecan, the Shagbark has given rise to several superior races, some of which are cultivated.

JUGLANS, L.

Pith chambered, with persistent thin diaphragms; buds frequently superposed, the terminal subnaked, their leaves valvately arranged; vernation of leaflets conduplicate (pl. 25, f. 1), catkins mostly elongating somewhat in early winter; fruit with indehiscent persistent husk.

* Leaf scars little notched at top, surmounted by a yellow-velvety transverse prominence.

1. J. CINEREA, L. — The Butternut. — A medium-sized tree; bark gray, rather smooth between the deep fissures; twigs reddish-buff, with staring hairs or soon nearly glabrous, with numerous small white lenticels; pith dark brown, with narrow chambers little wider than the intervening diaphragms; terminal buds longer than broad, densely yellow-pubescent, the outer scales lobed at apex; fruit elongated, the husk villous, the nut 2-celled at base.— New Brunswick to Dakota, Kansas, and the mountains of Georgia and Alabama.— Pl. 24, f. 1–4.

Three Asiatic species, related by their buds and leaf scars to the Butternut, are more or less cultivated in the United States: — *J. Sieboldiana* (pl. 25, f. 3), with pale closely set pith plates, puberulent brown twigs with conspicuous

elongated lenticels, terminal buds little longer than broad, and ovoid terete nuts with honeycombed surface; *J. Mandshurica* (pl. 25, f. 4), with dark closely set pith plates, nearly glabrous somewhat glaucous reddish-brown twigs with very minute and inconspicuous lenticels, elongated buds, the lateral mostly on stalks of their own length, and ellipsoidal ridged and pitted nuts somewhat resembling those of *regia;* and *J. cordiformis* (pl. 25, f. 2), with pale, rather remote pith plates, brown twigs beset with very numerous long stiff ultimately deciduous brown hairs, the lenticels elongated but mostly inconspicuous, somewhat elongated buds often strongly curved to one side, and ovoid sharply acuminate strongly flattened and 2-edged nuts with nearly smooth surface.

* * Leaf scars evidently notched, not surmounted by a tomentose elevation; nut subglobose, somewhat 4-celled at base.

+ Western species: terminal buds elongated, their outer scales lobed above: fruit mostly small, the nut often only shallowly grooved and then with smooth rounded ridges.

2. J. RUPESTRIS, Engelmann.— The Southwestern Walnut.— A shrub or small tree; bark rather thick, gray, scaly; twigs slender, gray with a tinge of red or yellow, at first very densely buff-gray tomentose, the tomentum at length falling with the epidermis and exposing the small rounded pale lenticels; pith very small, brownish, with chambers several times as wide as the thin diaphragms; terminal buds twice as long as broad, somewhat olivaceous; nut often erosely roughened.— Texas, New Mexico and Arizona, extending into Mexico.— Pl. 24, f. 5–7.

3. J. CALIFORNICA, Watson.— The Californian Walnut.— A small or medium sized tree; bark thin, from whitish becoming dark brown; twigs stouter, glabrous except occasionally at the tip, and brown after the falling of the silvery epidermis, lenticels pale, very small but evident; pith large, slightly darker, otherwise as in the last; terminal buds somewhat less elongated, of the color of the twigs or gray-

ish; nut less deeply grooved.—Coast range of Southern California.—Pl. 24, f. 8–10.

+ + Eastern; terminal buds scarcely longer than broad, gray, their scales usually not evidently lobed; fruit large, the nut with prominent rough and sharp ridges.

4. J. NIGRA, L.—The Black Walnut.—A large tree; bark dark, deeply fissured and rough; twigs from densely gray tomentose becoming glabrous and reddish-buff, with small pale rather inconspicuous lenticels; pith buff, the open chambers usually several times as wide as the thin diaphragms; terminal bud mostly globose-conical, often almost silvery.—Massachusetts to Ontario and Minnesota, south to the Gulf.—Pl. 24, f. 11–13.

The European Walnut, *J. regia*, commonly cultivated in California, and to a less extent in the Atlantic States, resembles the last except that its bark is smoother and paler, and its twigs redder, often with a decided shade of green, mostly more dilated at the nodes and with broader more equally 3-lobed leaf scars, and glabrous, as are the lateral buds ultimately. In its typical form, the fruit is represented by the rather smooth thin shelled English Walnuts of the market.

Trees with the general characters of *regia*, but the fruit more or less resembling *nigra*, constitute the *Juglans intermedia* of European botanists,* some of whom hold these forms to represent hybrids between the two species named, while others are disposed to regard them as extreme forms of *regia*. Some years since Professor Rothrock † described a very peculiar walnut from the James River, in Virginia, and a somewhat similar fruit has been sent to our herbarium from the Wabash bottoms, by Dr. Schneck. More or less similar trees have been cultivated in European gardens, from American seed.‡ It is probable that some of these

* See, for instance, Robinson, Garden, ix. 363.

† Forest Leaves, ii. 133, with figures.

‡ See Vilmorin, Garden and Forest, iv. 51, with figures; Carrière, Revue Horticole, 1860, 100, and 1863, 30.

are actually of hybrid origin, while others, like the tree of Dr. Schneck, and those occurring spontaneously in Europe, are probably only aberrant forms respectively of *nigra* and *regia*. Quite recently Professor Sargent * has described and figured what he regards as a hybrid between *regia* and *cinerea*, the twigs of which are much more like those of *regia* than those of either of the supposed spontaneous hybrids that I have seen, though with more elongated buds and sometimes a little pubescent in the axils of the notched leaf scars. In the same article mention is made of several artificial hybrids produced in California by Mr. Luther Burbank, between *Californica* and both *nigra* and *regia*. Twigs of the first of these hybrids, for which I am indebted to Mr. Burbank, are downy and closely resemble those of *nigra* except that their gray terminal buds are usually twice as long as broad; while the twigs of the second are very stout, glabrous, and with large globose loosely gray tomentose buds.

EXPLANATION OF PLATES ILLUSTRATING JUGLANDACEAE.

The half-tones are from photographs taken by the author or contributed by correspondents whose donations are indicated in the description. The other plates are from drawings made by Miss Grace E. Johnson under the author's direction. Twigs, fruits and nuts are of natural size; twig details × 3.

Plate 1.—*Hicoria Pecan*, an old tree 16 ft. in circumference, near Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 2.—Bark of *Hicoria Pecan*, Caruthersville, Mo.

Plate 3.—Group of *Hicoria aquatica*, Campbell, Mo. Photographed by James Oxley.

Plate 4.—Bark of *Hicoria aquatica*,—one of the trees of Plate 3.

Plate 5.—*Hicoria minima*, Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 6.—Bark of *Hicoria minima*, St. Louis, Mo.

Plate 7.—Bark of *Hicoria glabra*, Ithaca, N. Y. Photographed by Professor Rowlee.

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* Garden and Forest, vii. 434; Silva, vii. 114.

Plate 8.— Bark of *Hicoria glabra*, var. *odorata*, Allenton, Mo.

Plate 9.— Bark of *Hicoria glabra*, var. *villosa*, Allenton, Mo.

Plate 10.— Bark of *Hicoria glabra*, var. *microcarpa*, Allenton, Mo.

Plate 11.— Bark of *Hicoria alba*, St. Louis, Mo.

Plate 12.— *Hicoria ovata*, near Mt. Carmel, Ill. Photographed by Dr. Schneck.

Plate 13.— 1–3, *Hicoria Pecan*; 4–6, *H. aquatica*; 7–9, *H. myristicaeformis*; 10–12, *H. minima*.

Plate 14.— 1, *H. glabra*; 2. *H. glabra, microcarpa*; 3–5, *H. glabra, odorata*; 6, *H. glabra, villosa*; 7–9, *H. alba*.

Plate 15.— 1–3, *H. alba*; 4–5, *H. laciniosa*; 6–9, *H. ovata*.

Plate 16.— 1–3, *H. aquatica*; 4–6, *H. minima*; 7–10, *H. Pecan*; 11, aberrant fruit of *H. Pecan* from Texas (Reverchon); 12–14, *H. Pecan* × *minima* (Galloway); 15–16, *H. Pecan* × *minima* (Reppert).

Plate 17.— 1–4, *H. myristicaeformis*; 5–6, *H. glabra*; 7–8, *H. glabra, microcarpa*; 9–14, *H. glabra, odorata*.

Plate 18.— 1–2, *H. glabra, villosa*; 3–10, *H. alba*.

Plate 19.— 1–3. *H. Mexicana*; 4–5, *H. laciniosa*; 6–7, *H. ovata*.

Plate 20.— *H. Pecan* × *minima* (Galloway), flowering shoot and winter twig, natural size; staminate flower, × 6.

Plate 21.— *H. Pecan* × *alba* (Schneck), twig and foliage, natural size.

Plate 22.— *H. Pecan* × *laciniosa* (Schneck), twig and foliage, natural size.

Plate 23.— 1, Vernation of *Hicoria*, after Engelmann; 2–5, *H. Pecan* × *alba* (Reppert); 6, *H. Pecan* × *laciniosa* (Schneck); 7–9, *H. Pecan* × *laciniosa* (Nussbaumer).

Plate 24.— 1–4, *Juglans cinerea*; 5–7, *J. rupestris*; 8–10, *J. Californica*; 11–13, *J. nigra*.

Plate 25.— 1, Vernation of *Juglans*, after Engelmann; 2, *J. cordiformis*; 3, *J. Sieboldiana*; 4, *J. Mandshurica*.

Since the preceding pages were cast, a bulletin on Nut Culture in the United States has been published by the Division of Pomology of the United States Department of Agriculture, which contains valuable information on the cultivated varieties of *Hicoria* and *Juglans* as well as good illustrations of the fruit of several species. The supposed hybrid pecan referred to above under *J. laciniosa*, is here (p. 62, pl. 9, f. 6) reported further from Mt. Vernon, Ind.

HICORIA PECAN.

HICORIA PECAN.

HICORIA AQUATICA.

HICORIA AQUATICA.

HICORIA MINIMA.

HICORIA MINIMA.

HICORIA GLABRA.

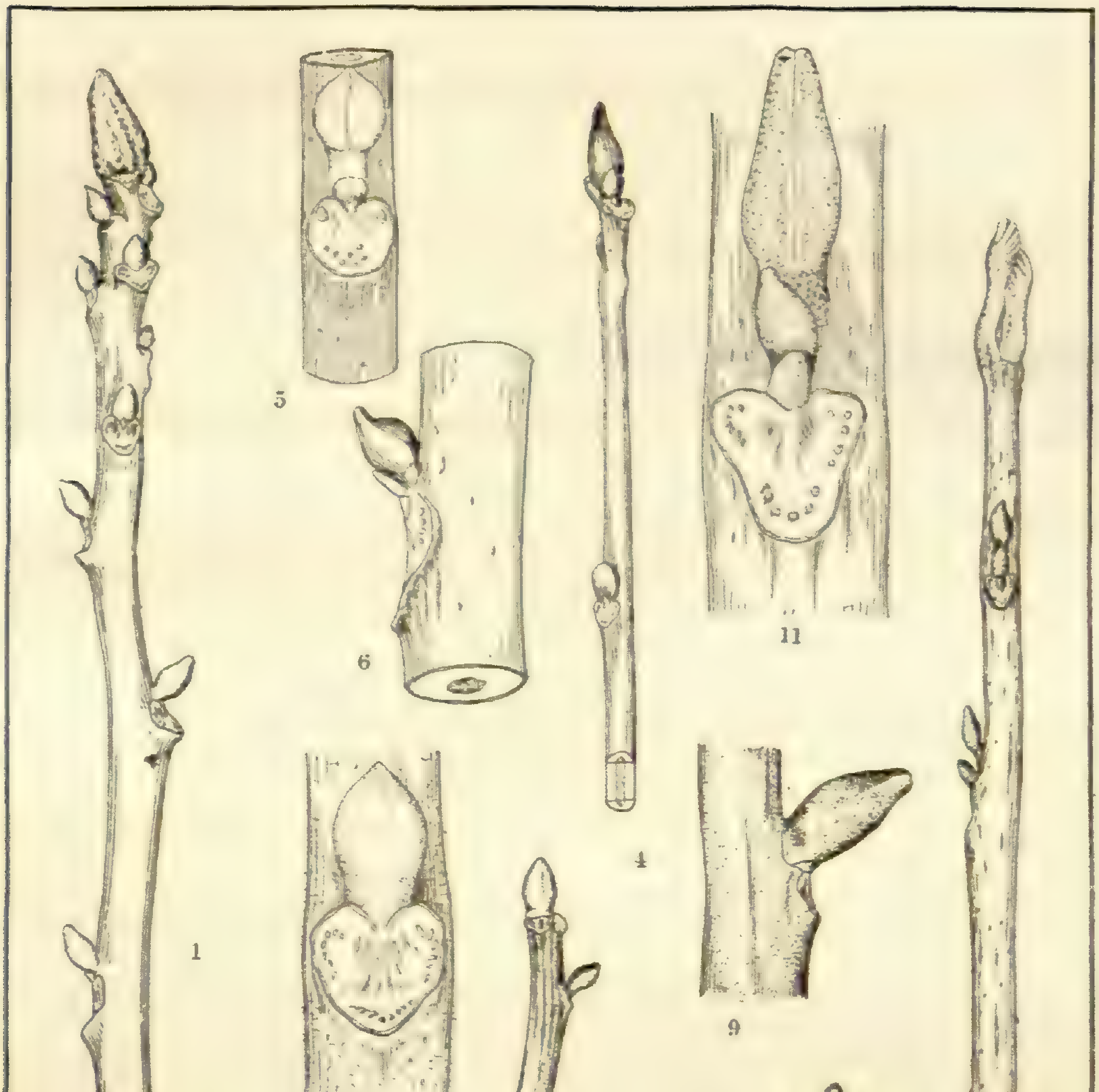
HICORIA GLABRA, VAR. ODORATA.

HICORIA GLABRA, VAR. VILLOSA.

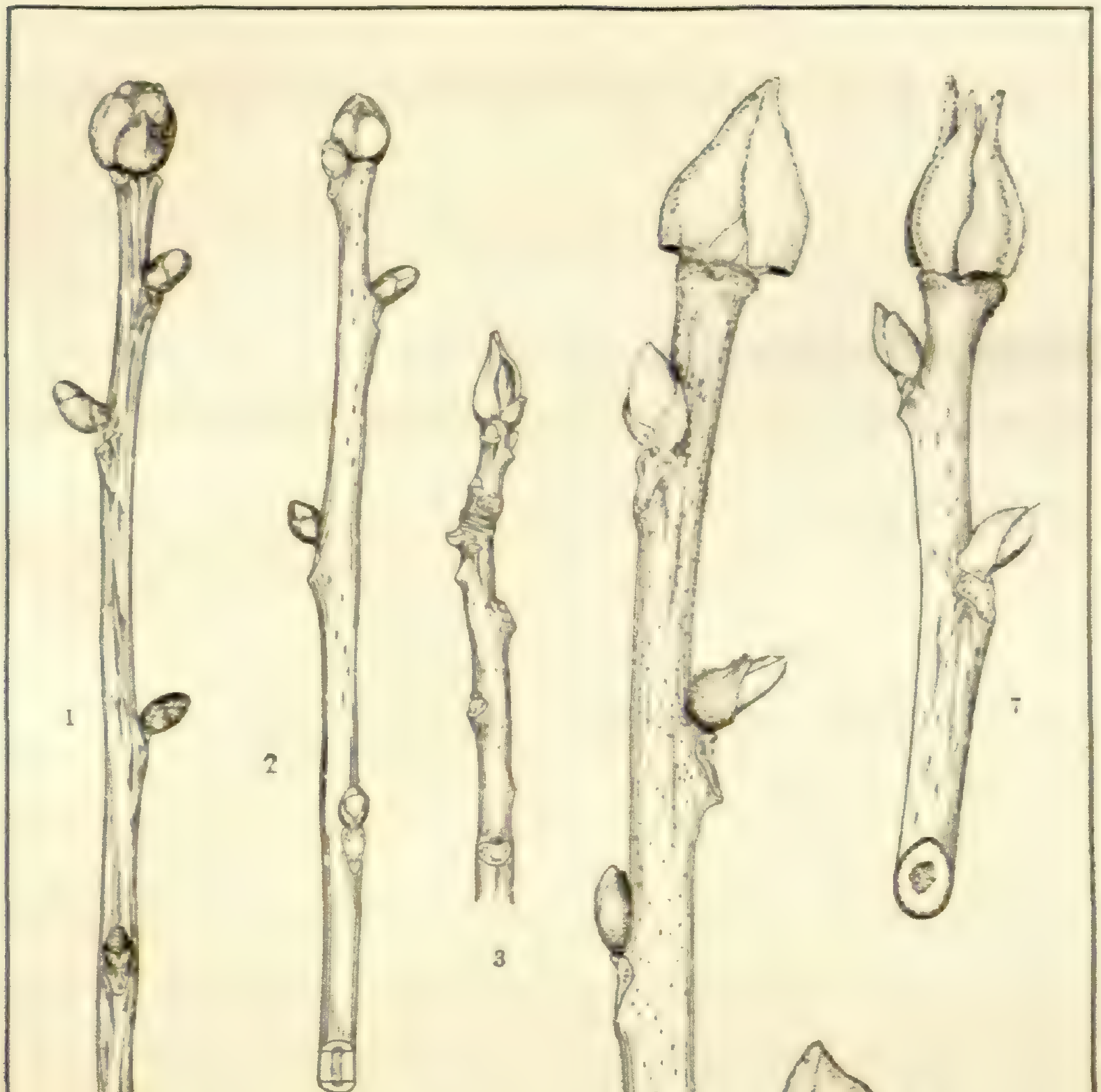
HICORIA GLABRA, VAR. MICROCARPA.

HICORIA ALBA.

HICORIA OVATA.



HICORIA, SECTION PACANIA.



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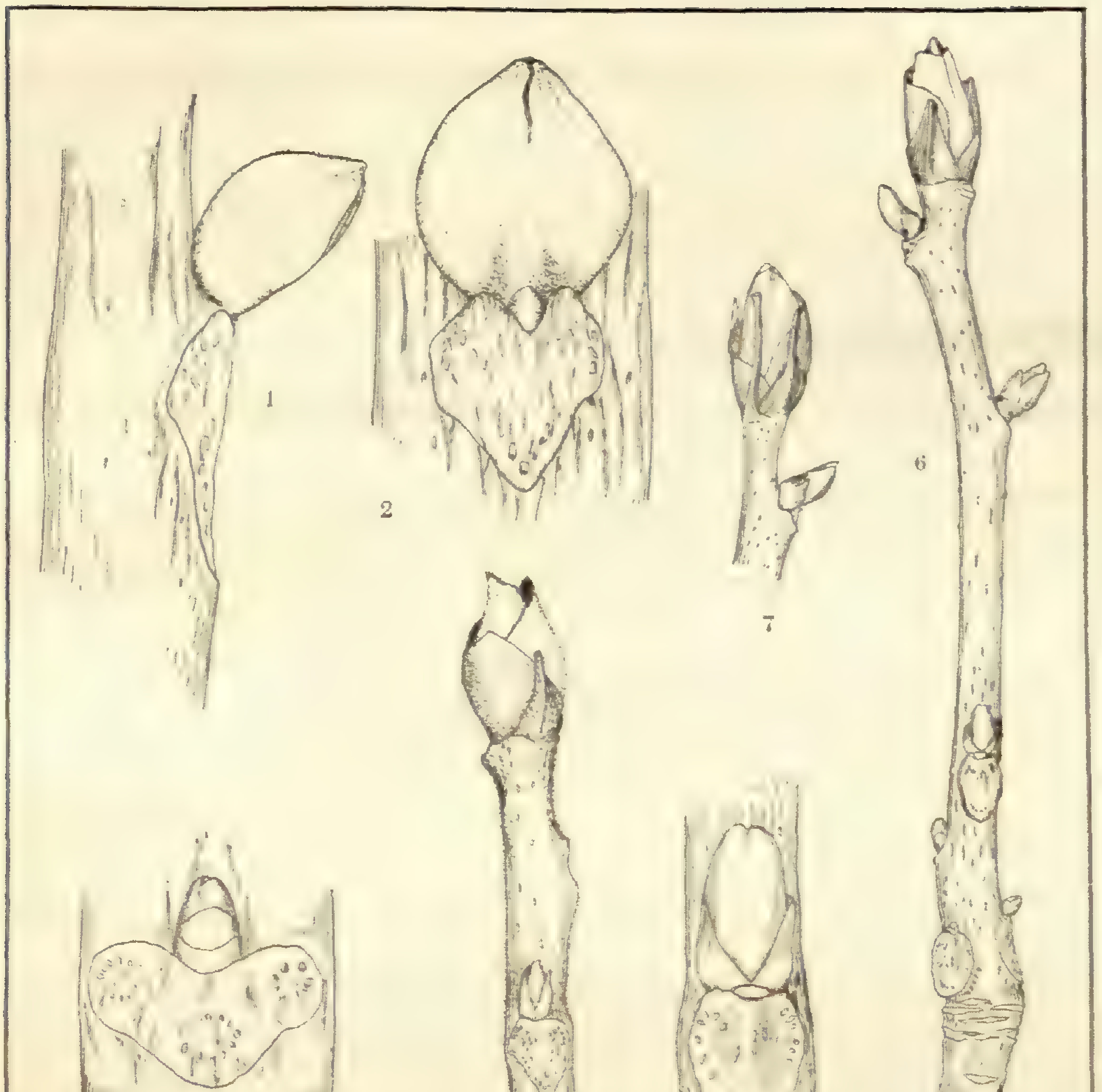

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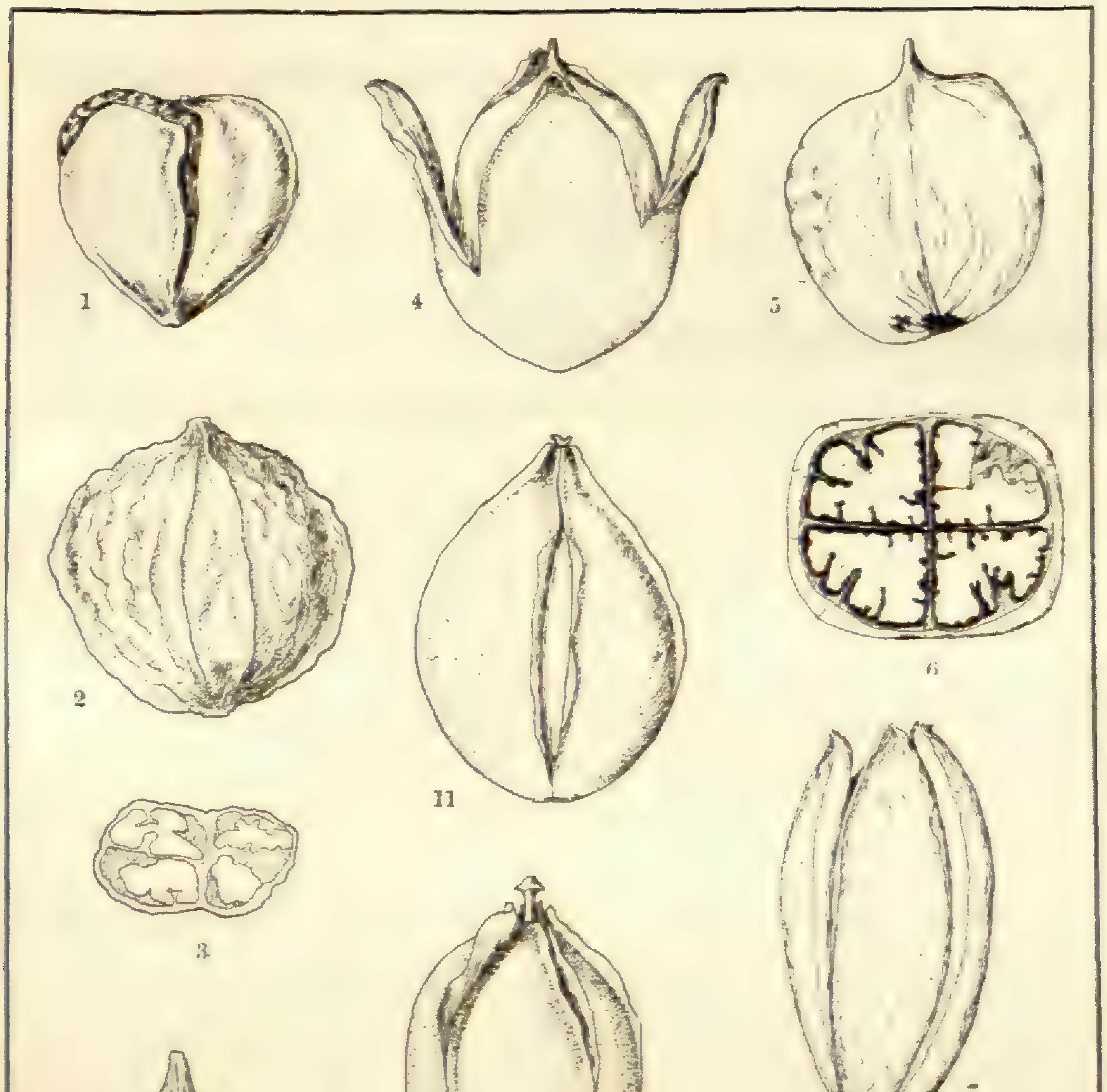
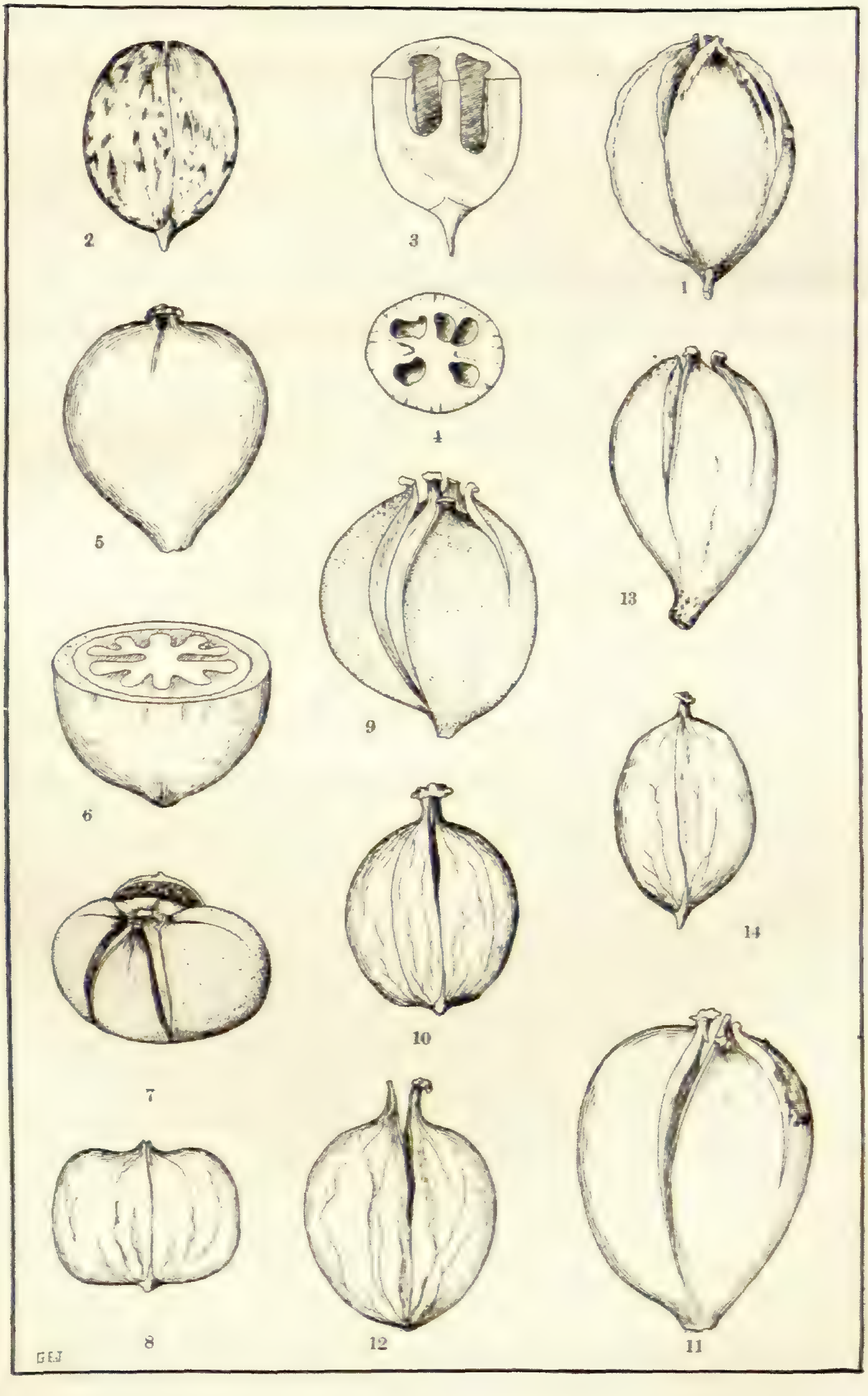
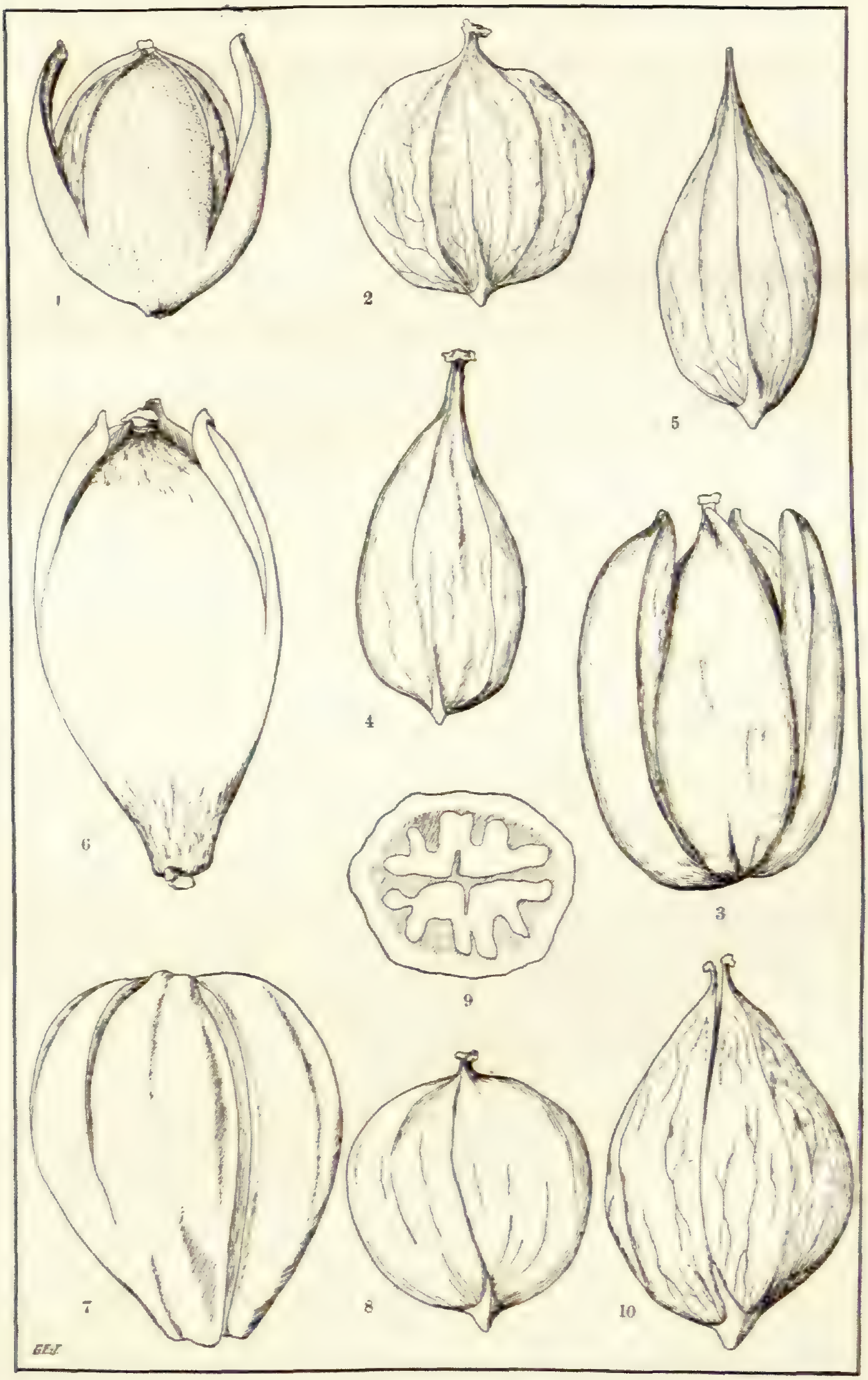


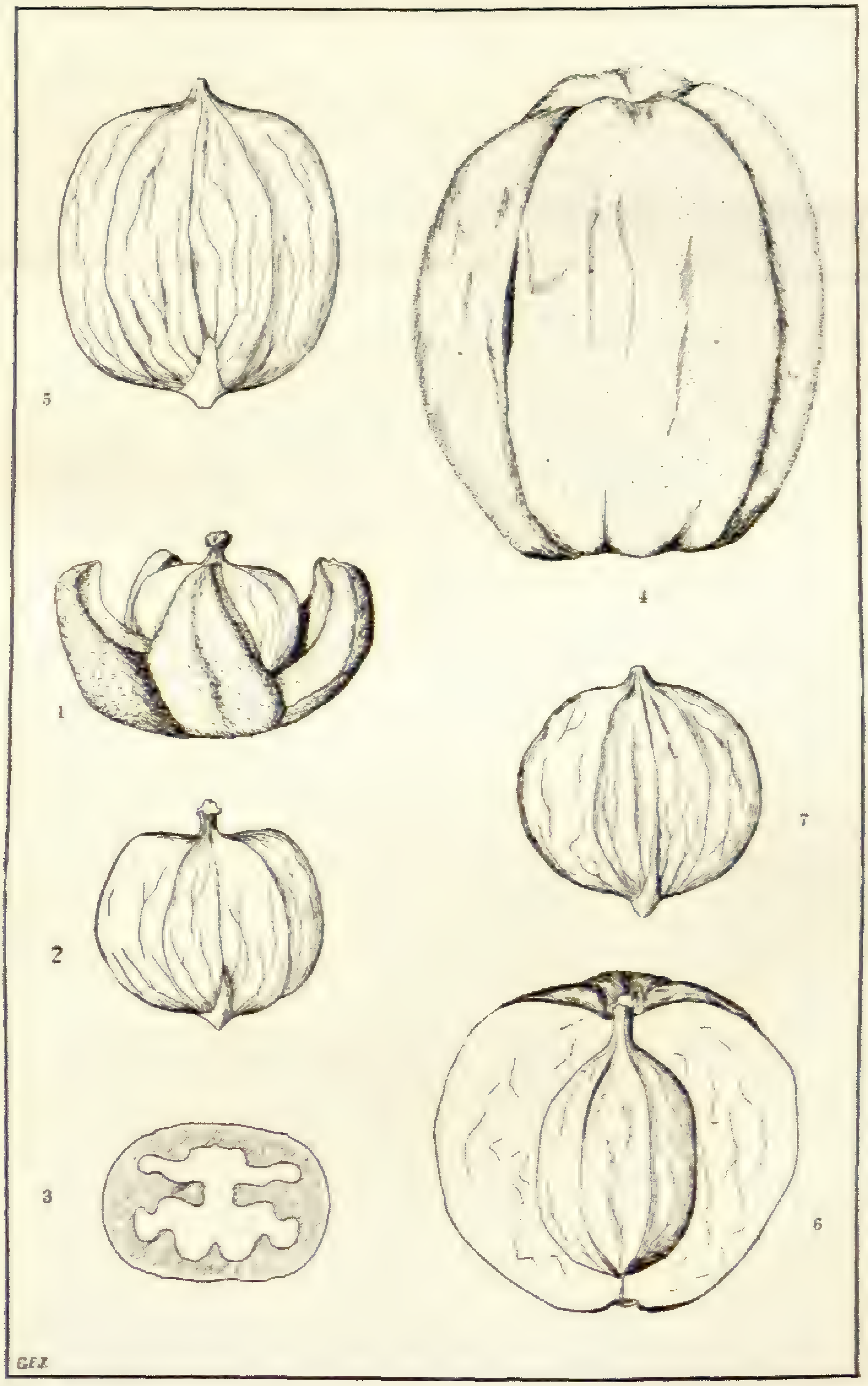
HICORIA, SECTION PACANIA.



NUTMEG AND PIGNUT HICKORIES.



HICORIA, SECTION EUHICORIA.

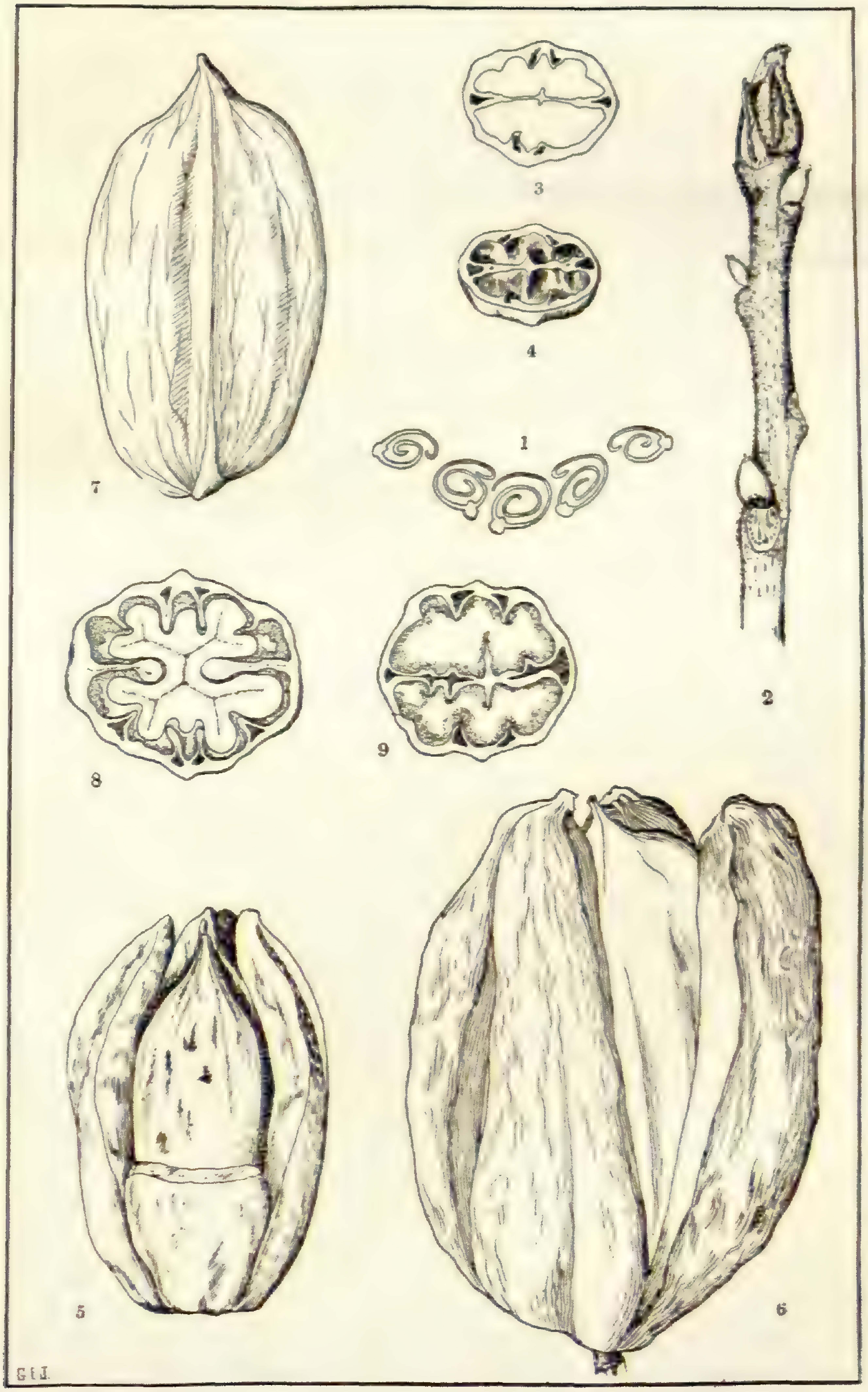


HICORIA, SECTION EUHICORIA.

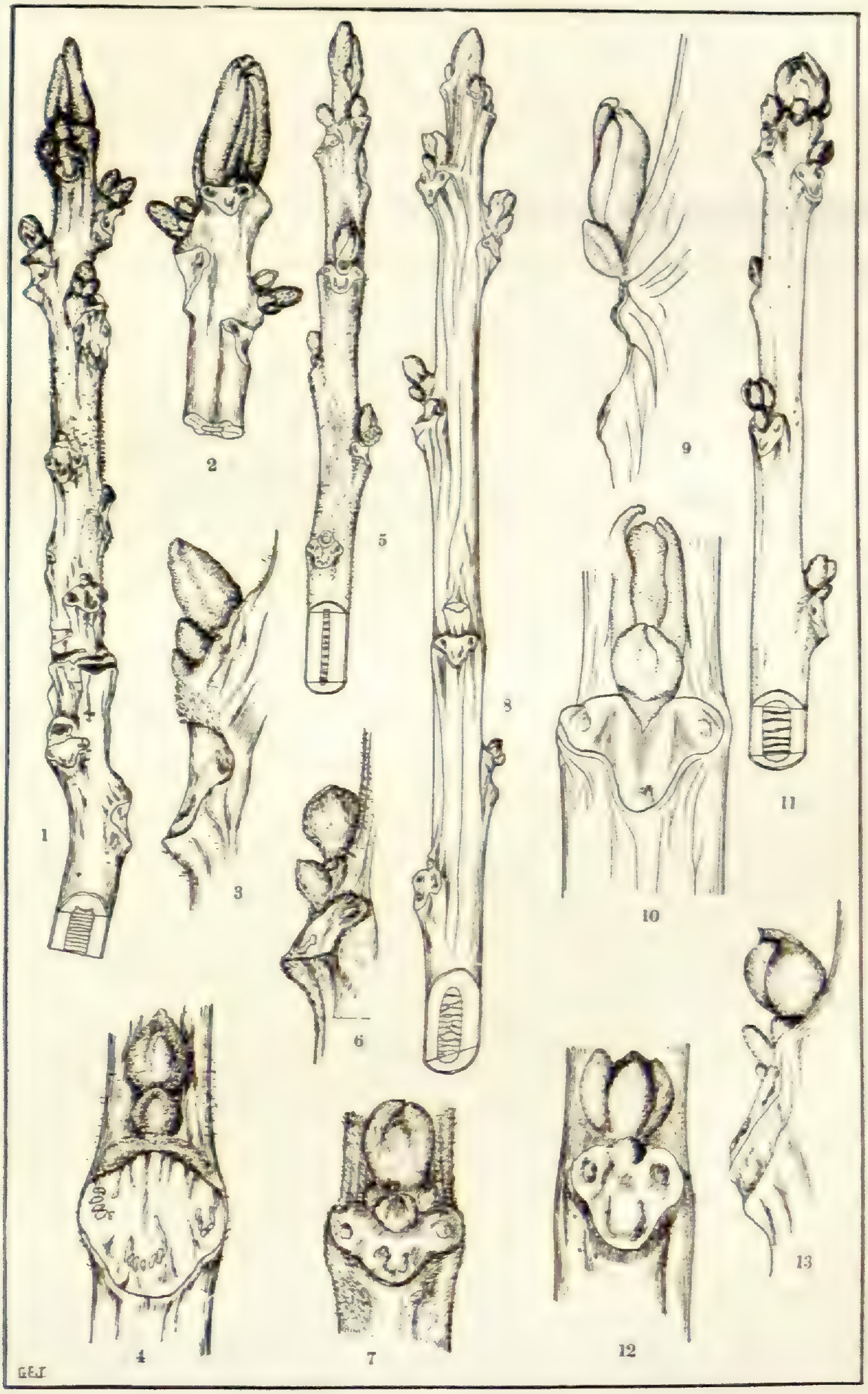
HICORIA PECAN × MINIMA.

HICORIA PECAN × ALBA.

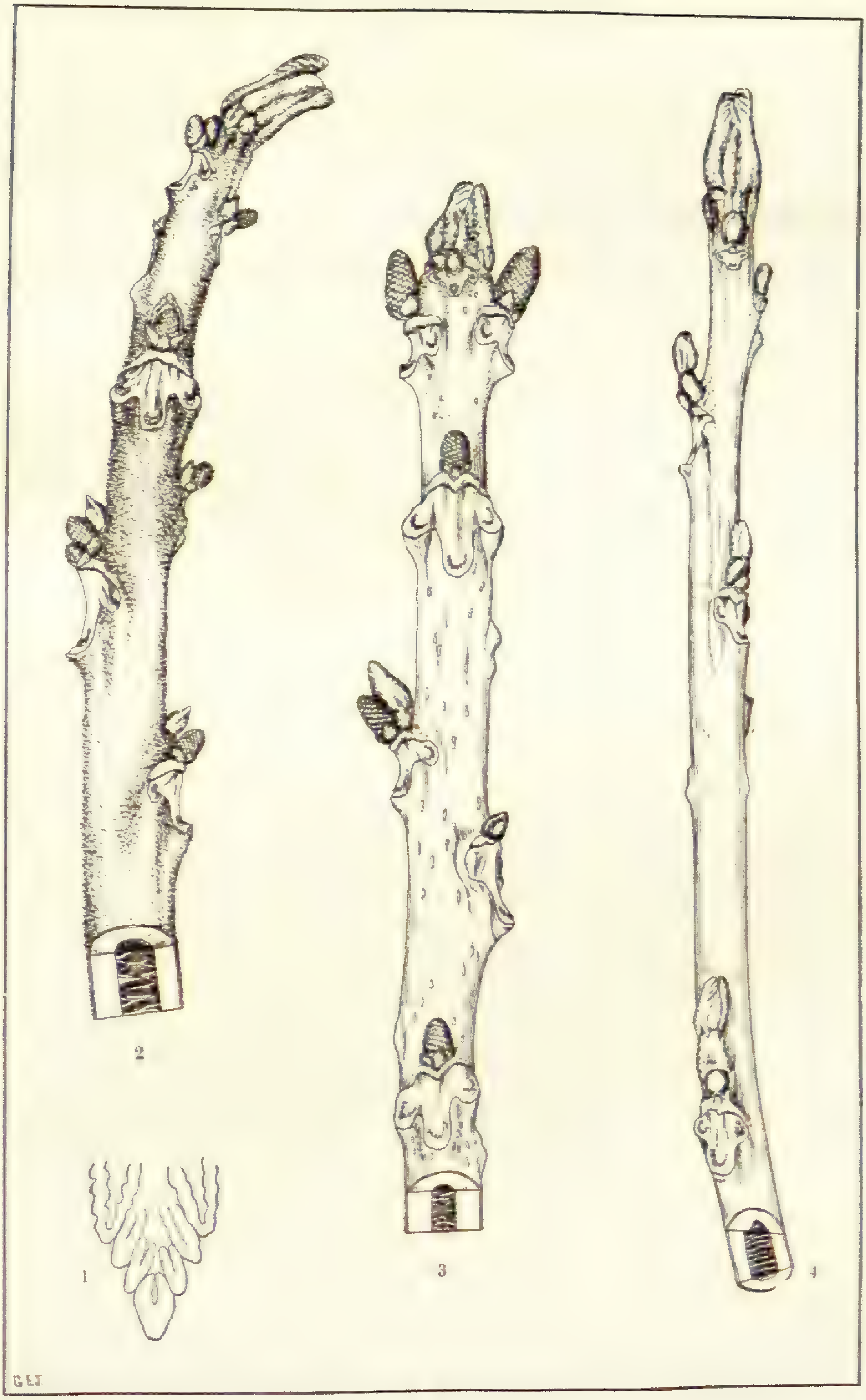
HICORIA PECAN × LACINIOSA.



HICORIA HYBRIDS.



AMERICAN WALNUTS.



JAPANESE WALNUTS.

A STUDY OF THE AGAVES OF THE UNITED STATES.*

BY A. ISABEL MULFORD.

A GENERAL ACCOUNT OF THE GENUS.

Jacobi,† Koch,‡ Terraciano,§ and Baker‖ in their works upon the genus Agave have all given attention to forms occurring within our territory. Dr. John Torrey made a good study¶ of those collected in connection with the Survey of the United States and Mexican Boundary under Lieutenant Emory. But Dr. Engelmann's ** able paper still remains the only monograph specially devoted to our species, and is still the most complete and best authority concerning them. In connection with his manuscript notes and drawings relating to the genus, it forms one of the many monuments of his skill and patient industry.

During the years that have intervened since 1875, our southwestern territory has been more extensively explored and is much better known. It was hoped that a further study of this genus might add to our knowledge of its species, and of their distribution. No place could be more appropriate for such a work than the Missouri Botanical Garden. In its large succulent house the collection of our own and foreign

* Revised from a paper written as a thesis in connection with work for the degree of Ph. D. in Washington University, June, 1895.

† G. A. von Jacobi, Versuch zu einer systematischen Ordnung der Agaveen. 1864. Zweiter Versuch, etc. 1870. Hamburg.

‡ Karl Koch, Agaveen Studien. 1865.

§ Achille Terraciano, Primo Contributo ad una Monographia delle Agave, Napoli. 1875.

‖ J. G. Baker, Handbook of the Amaryllideae, London. 1888.

¶ J. Torrey, Botany of the Boundary, 1858, 213.

** Transactions of Academy of Science of St. Louis, iii. 291 to 322. Reprint issued December, 1875, 3 to 35. Botanical Works of George Engelmann. Collected for Henry Shaw, 1887, 300 to 325.

Agaves is probably the most extensive in the United States. It was the scene of Dr. Engelmann's labors. It still contains many of his plants, and young plants raised from them. Its herbarium contains his type specimens, manuscript notes, drawings, and reference books, in connection with its large collection and library.

Every possible facility has been afforded me in this study. Much trouble has been taken to open correspondence with residents in the Agave regions, and to obtain fresh material from the field. I am grateful for the opportunities given, and very especially so to Dr. Trelease; had it not been for his kindly suggestions, encouragement and assistance, the work would not have been possible.

I have also had the use of the specimens in the Gray Herbarium of Harvard University, and the herbaria of Columbia College and the United States Department of Agriculture. I wish to express my thanks to Dr. Robinson, Dr. Britton and Dr. Coville for the use of the material in their charge, and to Mr. T. S. Brandegee for the use of his private collection.

Thanks are also due, for much courtesy and assistance, to the following persons: —

Professor P. H. Rolfs, of Lake City, Mr. H. J. Webber, of Eustis, Mr. C. T. McCarty, of Ankona, Mr. Kirk Munroe, of Cocoanut Grove, Florida; Mr. C. G. Pringle, of Charlotte, Captain John G. Bourke, U. S. A., of Fort Ethan Allen, Vermont; Dr. J. T. Rothrock, of West Chester, Pennsylvania; Mr. C. R. Dodge, of Washington, D. C.; Dr. E. A. Mearns, U. S. A., of Fort Myer, Virginia; Dr. B. D. Ten Eyck, U. S. A., of Eagle Pass, Dr. B. D. Taylor, U. S. A., of Fort Bliss, Professor C. H. Tyler Townsend, of Brownsville, Mr. G. C. Nealley, of Corpus Christi, Mr. J. N. Gilcrease, of Sierra Blanca, Mrs. Anna B. Nickels, of Laredo, Mrs. Maud M. Briggs, of El Paso, Texas; Mr. M. E. Jones, of Salt Lake City, Utah; Mr. C. R. Orcutt, of San Diego, Mr. S. B. Parish, of San Bernardino, Mr. F. Sutphens, of Witch Creek, California;

Dr. T. E. Wilcox, U. S. A., of Fort Huachuca, Dr. P. T. Straub, U. S. A., of San Carlos, Dr. Berkeley Macauley, U. S. A., of Fort Apache, Professor James W. Toumey, of Tucson, Arizona; Professor E. W. Wooton, of Las Cruces, Dr. James K. Kimball, U. S. A., of Fort Wingate, Mr. and Mrs. C. B. Allaire, of Deming, Mrs. D. C. Billings, of Las Cruces, Mrs. J. A. Baird, of Las Cruces, Mrs. Angus Campbell, of Cliff, and to Dr. and Mrs. W. O. Owen, Quartermaster James E. Brett, Captain and Mrs. A. C. Markley, and Colonel and Mrs. Jacob F. Kent, of Fort Bayard, New Mexico.

The work has been a most interesting one. It has opened up to me a number of questions, some of which, no doubt, could be soon answered by proper field work, while others would repay careful study through a series of years.

In the genus Agave, Baker * recognized one hundred and thirty-eight species, and quite a number have been since described. As our knowledge increases, it is probable that the number which will stand as legitimate species may be much reduced. Many descriptions have been made from plants growing in European greenhouses whose inflorescence is unknown. Some of the old descriptions are so meager as to give no certainty as to the plants described; others so minutely describe single conservatory plants whose counterpart has never been seen, that the names given probably stand for these isolated plants.

Young plants of a given species may differ from one another, and from the mature plants, so greatly as to be unrecognizable. Under the changed conditions in which they are obliged to live in greenhouses, these plants frequently develop peculiarities which may or may not repeat themselves in successive generations and which may or may not be found in the natural state.

Owing to the size and weight and formidable armor of the Agaves, as well as the difficulty in pressing and drying

* Handbook of the Amaryllideae. 1888. London.

so as to make good herbarium specimens, they have been very generally avoided by collectors, and consequently are poorly represented in herbaria. Those collectors who have been able to take the time and trouble necessary, have perhaps not found them in flower, and have been obliged to content themselves with leaves or parts of leaves; others seeing a plant in bloom have been interested in getting the flowers, and have found themselves sufficiently burdened without collecting the leaves. It is comparatively seldom that leaves, flowers, capsules, and seeds of a given species have been collected by one person or in one place. Quite frequently specimens have been selected because of something unusual in their aspect, while the ordinary form has been passed by with the assumption, fancied or real, that some one else has collected that. It is often hard to tell what herbarium sheets may or may not be placed together to represent a plant.*

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* Botanical collectors, are, as a rule, much interested in their "finds," and wish to have good work done with them. They are usually well aware of the fact that field notes of all salient points that cannot well be shown in dried specimens are very valuable. These should include notes of habit, surroundings, color of flowers, pollination, maximum, minimum, and average size. Where variable, it is very desirable that leaves should be selected representing different stages of development in both young and mature plants, and that careful notes of abnormal forms should be made. Cross-sections, and outlines and measurements of cross-sections are useful. The inflorescence, capsules and seeds should be well represented if possible. If the scape is a large one, cross or longitudinal sections of it and its branches, with bracts and flowers attached, could be taken. Some of the flowers should be split longitudinally and opened out in pressing.

The process of drying fleshy plants like Agaves can be much facilitated and improved by dipping their parts for a few seconds at a time in boiling water, and repeating the process till they are softened. Care should be taken not to injure the color of flowers by immersing them too long at a time.

Mr. C. G. Pringle, whose success with specimens is very marked, writes that he does not always scald the leaves, but that a week in press with two or three changes a day and exposure to the direct rays of the sun, suffices to dry the leaves of most species. He never scalds the flowers.

For all these reasons, it is very difficult for a student in the laboratory to decide upon the limits of a species or a variety, or to make satisfactory descriptions. An unsigned article* has recently appeared in one of our journals whose writer, while advocating the founding of a garden in Arizona for the cultivation of plants peculiar to our arid region, is led to say: "No group of American plants, with the exception, perhaps, of the Cacti, is more difficult to understand from specimens preserved in herbaria, and not much light is thrown upon these plants [Agaves], by the occasional isolated individuals which drag out a more or less miserable existence in the confinement of northern glass-houses. Labor expended in herbaria in the study of the plants we have mentioned, is practically thrown away, as it can only be partial, and never final."

Very little of our work can be regarded as complete or "final," and we should accomplish little if our efforts should cease for that reason. A desert garden would be a valuable acquisition. I can think of various questions I should like to see tested in a place where these plants could be systematically observed and compared under natural conditions, and where experiments could be well controlled. In the absence of such a garden, however, I think that much can be done in laboratory and field if good specimens are collected, and proper studies made.

We should be much assisted in forming correct ideas of the genus and the affinities of its species, if collectors would take habit photographs of the plants in their natural surroundings. Mr. C. G. Pringle, and Dr. T. E. Wilcox, have done valuable work of this sort.

When practicable, living plants should be sent to botanical gardens where they will receive care and study.

In this paper I have tried to bring together such information as I could gain concerning our Agaves from library, herbaria, conservatory and field, and to add what it was

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* "An Arizona Agave." Garden and Forest, May 8, 1895.

possible to learn in a short time through correspondence and the examination of all available living material. Dr. Trelease has kindly arranged to have the plants illustrated in such a way that they can be readily recognized. I shall be very glad if my work may serve as some stimulus to further collection and observation.

The Agaves occupy a prominent place amongst the characteristic plants of the hot and arid regions of our continent. The genus contains a pretty distinctly marked group including the largest and tallest of our herbaceous plants. Their flowering stalks sometimes rise to the height of forty feet or even more, and their conspicuous inflorescence renders them objects of great picturesqueness.

They are much prized by all who take an interest in the cultivation of plants. Few conservatories or gardens are without them. They make a most effective decoration for lawns, terraces, rockwork and pleasure grounds. Their large size, symmetry of form, stately and elegant proportions were well characterized by Linnaeus when he applied to them the name "*Αγαυή*," noble, admirable, wonderful.

By far the largest number of species have their homes in Mexico, Central America, and the Southwestern portions of the United States from Texas to California. Two or three forms are native to our Southern States, and a few perhaps to South America and the West Indies. A. Americana, the species most commonly seen in small collections, is native to the fertile soil of Opam in Southeastern Mexico, but it readily adapts itself to new localities. It has become naturalized in the Mediterranean region, in the West Indies and probably in Texas and Florida. Other species have become naturalized in Florida and the adjacent islands.

The thick fleshy leaves of Agaves generally have their broad bases imbricated over one another around a short axis, thus forming a compact tuft with comparatively little evaporating surface. The cuticle is adapted to resist transpiration. Roots and leaves contain large quantities of

mucilage, saponin and salts which hold water in solution with great tenacity, and enable the plants to survive through long protracted seasons of dryness incident to a land of almost perpetual sunshine. Like other plants with a well developed aqueous tissue, they may be justly compared to camels, the "ships of the desert."

Most species are armed with stout spines, marginal prickles, corneous margins, or dry fibrous filaments. These render efficient protection against the attacks of hungry and thirsty animals, who would gladly seize upon their juicy and nutrient substance.

Agaves usually grow slowly. In their natural habitats some attain maturity in three or four years, while others require ten to fifteen years or more. Taken from their homes and placed under new and strange conditions, they seldom make an effort to bloom. Although they respond to care, and grow into fine plants much prized in decoration, so rarely are their flowers seen that they have long been called "Century Plants," because of the old idea that they bloom once in a hundred years only.

When the period of inflorescence arrives, a great change is observed. The newer leaves are successively smaller and narrower; the central bud thickens, and after a season begins to shoot upwards with marvelous rapidity. What at first appear like narrow young leaves clustered around it, gradually become more and more separated by the elongating axis, and are seen to be bracts placed upon it at regular intervals.

Dr. Engelmann* gives a fine description, accompanied with illustrations, of the flowering of A. Shawii at the Missouri Botanical Garden (Plates 44 and 47.)

A plant here (Plates 62 and 63, Figs. 5, 6, 7), labeled A. horrida micracantha, commenced to send up a flower stalk early in November, 1894. Daily measurements of growth

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* Transactions of St. Louis Academy, iii. 371. Collected writings, 314 to 320.

were made. For twenty days after November 16th, this averaged two and three-fourths inches per day. After that its average increase gradually lessened, and more of its strength was used in the development of the flower buds. Flowers began to open the first week in January, and the last ones opened the second week in February. The plant matured an abundance of fruit before the middle of June and the leaves were then seen to be rapidly dying off.

After the great expenditure of energy displayed in producing flowers and fruit, the vitality is usually exhausted. The plants generally send out suckers or offsets, and then quickly die and give place to the next generation. This, however, is not an invariable rule. The species bearing annual leaves, may bloom annually, and Nicholson's Dictionary of Gardening states that A. Sartorii does. A plant of A. Ghiesbrechtii which bloomed in this garden three years ago, but which formed no fruit, still shows no signs of decay. A. Engelmanni, named and described by Dr. Trelease,* bloomed here in 1890, and lived until the summer of 1894.

A plant here named A. heteracantha by Mr. Baker of Kew, was raised from seed sent to the Garden about seventeen years ago. This never suckers like our A. Lechuguilla, but is strongly caulescent. Its offsets or branches of the main stem crouch rather closely to the ground, giving a straggling effect to the whole. Many new buds are now starting also from the axils of older leaves. This plant bloomed here for the third time in January, 1892. It has a very healthy appearance and is now sending up flowering stalks from two of the side branches.

A correspondent of the Gardener's Chronicle † states in substance that mostly all of the forty-eight American Aloes that bloomed in the gardens of T. A. Dorrien Smith, Esq.,

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* Third Annual Report, Missouri Botanical Garden, 1892, 167, Pl. 55, 56.

† June 1877, 820.

Tresco Abbey, Isles of Scilly, in 1875, were still living in 1877. One flowered in 1876. This had been damaged and had lost its central spike by being overgrown by a large Fuchsia. It afterwards threw up three small spikes from the axils of its lower leaves.

Other cases* of lateral inflorescence are noted. Dr. Goeppert in Regel's Gartenflora,† describes some interesting ones. A large Agave (in Botanical Garden of Löwen) produced a large terminal inflorescence, and in the following year five lateral ones, and finally in the third year an extraordinary number of flowering stems, some of them bearing only one flower. He further states that when the French landed in 1830 at Sidi Ferruh, they found the neighborhood of Algiers thickly studded with Agaves. In the summer of 1831, not one of these plants bloomed, and it having been determined to form a camp many of the soldiers amused themselves by beheading the Agaves. In 1832 all these multilated Agaves threw up flower spikes, and more than fifteen hundred were crowned with flowers at one time, affording a magnificent spectacle. When lateral flowering occurs, it often seems to be the result of an injury to the central axis which sends its strength into a side bud, making it in its turn a terminal bud.

The propagation of the Agaves is easy and rapid. Seeds are produced in great quantities and, under favoring conditions, readily germinate. The cotyledon is long and narrow and bears the seed-coat at its apex until fully matured. (Plate 63, Figs. 2, 3, 4.)

Many species while quite young also produce an abundance of suckers or offsets which frequently form a circle of progeny around the parent plant. In the Death Valley Expedition, near Mountain Springs, in the lower part of the piñon belt, Charleston Mountains, Nevada, a " tuft of A.

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* Lachaume, Revue Hort. 1876, 182; Gard. Chron. May, 1876, 696; S. B. Parish, Erythaea, 1893, 44; Gard. Chron. 1883, 370.

† Vol. xxvii. 1878, 307. Gard. Chron., Jan., 1879, 50.

Utahensis * was seen with forty-two well developed heads besides many smaller ones growing from a single root."

Dr. E. L. Greene† describes a remarkable case of abnormal flowering of A. applanata Parryi. "The mature central and parental member of a cluster of plants on coming into flower, had communicated its floriferous energy to all its offspring, great and small, and there were eight or ten of them, each of which bore at the same time its scape of flowers."

A number of species belonging to the Euagave section are viviparous. Young plants or bulbilli are produced on the branches of the scape in place of, or in connection with, the capsules. These give a queer appearance to the plant while they still remain attached. They eventually fall to the ground, take root, and grow into good plants.

On page 53, a plant labeled A. horrida micracantha, which bloomed at the Garden last winter, was spoken of. A few weeks after the flowering had ceased and while the abundant fruit was being rapidly matured, quite a large number of bulbilli appeared just below the apex of the scape, at about the point where the flowers had ceased to form. A similar development has been observed elsewhere upon a plant of the Littaea section.‡

Thus protected and defended, thus prepared in so many ways to propagate their species, the Agaves are seen to be well fitted to sustain life in the desolate barren mountains and superheated valleys to which they have been assigned. Their vitality is most wonderful. Plants are frequently taken up by the roots and kept for months with no water or care of any kind, and afterwards on being planted, show good growth.

Unfortunately, little is known in regard to the pollination of these plants. Bees and flies are seen upon them. Though some flowers of the species in bloom here last

* Contributions from the U. S. National Herbarium, iii. Nov. 29, 1893, 201.

† Erythaea, 1893. i, 52. ‡ Engelmann, Collected Writings, 308.

winter were pollinated artificially, most of the others also matured their fruit, and showed that the pollen from upper flowers must have done its work upon the stigmas of the lower ones.

Why the flowering stems of some Agaves should attain so great a height is not easily explained. I am told by residents of New Mexico that the red-polled sparrow and other birds are seen to visit the inflorescence of A. applanata Parryi. This species produces an enormous quantity of sweet nectar. If birds or high-flying insects assist in pollination, the task of finding the flowers would evidently be much facilitated by their commanding position.

The height doubtless assists in disseminating the seeds to a greater distance than would otherwise be possible. As the capsules open from above, the swaying of the poles must cause the seeds to be caught by the air currents as they are dislodged; being thin and flat they may be carried to a considerable distance beyond the circle of progeny formed by suckers, before reaching the ground.

It is stated that certain Agaves are hybridized* in cultivation. If this is readily accomplished, it can be inferred that similar instances may occur in a state of nature, and upon this basis, explanations may be made of some of the queer freaks and differences of form so often observed.

I have been able to secure but slight information in regard to the enemies of the Agave. They are injured by an insect (Scarabaeus†) called Maax (pronounced maash) by the Mayas. This bores through the center of the plant and destroys the softer parts. In cultivation the natives hunt this insect daily with pointed sticks and fill up the holes with pebbles and soil. Domestic animals, especially cattle, hogs and goats, are very fond of these plants when young, and will even chew the mature leaves for their juice.‡

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* Gard. Chron. April, 1877, 438.

† Agric. Report. 1869, 257. Riley, Insect Life, 1890 and 1891, 432.

‡ Agric. Report, 1869.

Previous to the heavy rains and floods in our Southwestern territory during the past summer very little rain had fallen for three years. The beds of most streams were perfectly dry and even the Rio Grande carried very little water. Scarcely a vestige of green vegetation was to be seen except in the cañons far up in the mountains. We saw the cattle lying upon the hills dead and dying. Those which survived had done so only through the most terrible straits. Many of them in their desperation were glad to feed upon even the older Agaves and the Cacti; and I was told that it was no uncommon thing to find their tongues pierced through and through with a network of the terrible spines.

ECONOMIC USES.

From time immemorial these plants have been utilized in various ways. The Aztecs showed their appreciation by reverencing "Mescal" or the Agave, as one of their gods under the name of Quetzalcoatl.*

The Aztecs, Mayas and other inhabitants of the country have made saddle-cloths, sacks, ropes and other articles from the fibers. The softer parts have afforded them important articles of food and drink and a soapy liquid for washing. The flowering stalks made handles for their lances, poles for fishing, and walls for their houses. Of the central shoot† of the Mescal the Apaches made their fiddles (Captain Bourke unfortunately is not willing to indorse the music). The end-spine with attached filament served as needle and thread. When General Crook went in March, 1886, to treat with Geronimo, in the Chiricahuas, he found him and his Indian warriors in a rancheria whose buildings were constructed of Agave and Yucca stalks.‡

* "On the Border with Crook." Captain John G. Bourke. 1891. 10.

† Captain John G. Bourke. Folk Foods of the Rio Grande Valley and Northern Mexico, in American Folk Lore, April, 1895.

‡ On the Border with Crook. Captain John G. Bourke. 476.

Professor W. J. McGee, who has just visited the savage Siri tribe on Tiburon island in the Gulf of California, obtained from them necklaces made of pretty seeds strung on maguay fibers. Humboldt tells of a bridge at Quito, having a span of one hundred and thirty feet, made of ropes of Agave fiber four inches in diameter. It is said that Agave juice is mixed with wall-plaster and used as an insecticide to keep out the white ants which are so destructive in tropical countries. The spiny leaves of the Agave have caused it to be used very effectively as a hedge plant in the Mediterranean region. Its leaves are sometimes cut in slices and used as fodder for cattle. Its flower-stem dried is used to make excellent razor strops * and scouring material.

In A. Lechuguilla, the connective tissue, according to Dr. Havard† "constitutes about 40 per cent.of the green leaf; when dried it is a white or yellowish mucilaginous powder, which possesses remarkable cleansing properties, principally due to the presence of saponin. Its composition is very probably analogous to that of Yucca baccata. Rubbed with water, it foams and lathers, answering the purposes of good soap, without, owing to its freedom from alkali, its disadvantages. It imparts a smooth and satiny appearance to the skin, and is used successfully in removing stains from the most delicate fabrics. It tends rather to set than to displace colors, and articles likely to fade may be washed with it in safety. It is also an excellent wash for the scalp and hair, leaving the latter soft and glossy. If the powder could be compressed into small cakes or tablets, it would doubtless become an important article of trade." The A. Schottii of Southern Arizona is also extensively used as an amole, or soap-producing plant. The Mexicans and Indians sell it in the towns for this purpose.

Under favorable circumstances the A. Americana, or

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* Peter Henderson, Handbook of Plants. 1881.

† Proceedings of National Museum. 1885. 518.

Maguay, the species most generally known as the Century Plant, will bloom at ten years of age. At the time it is ready to send up its flowering stalk, a most remarkable upward flow of sap takes place to meet the new demands. The liquor, called "agua de miel," or honey-water, is very sweet, and the Mexicans and Indians find it much to their taste. They cut out the central bud and leaves, and insert a long, cylindrical gourd to receive the liquor. Some plants produce an average of two gallons per day, and keep up the supply for months.

Pulque, a universal drink in Mexico, is made by collecting considerable quantities of the "miel" in vats made of rawhide, and causing it to ferment. This liquor, which at first was greenish or yellow, is now white and appears much like half-turned buttermilk. It has a strong yeasty odor. Though it is said to acquire a strong taste from its reservoir, foreigners, as well as the Mexicans, acquire a taste for it, and it has become an article of commerce. It is said to be cool, refreshing, palatable and nutritious. The A. Mexicana is also used in the manufacture of pulque. Mr. Baker* states that the A. atrovirens is the species especially used. I find the A. Americana most frequently mentioned. Mr. Dodge† states that it is made from any species with a crown sufficiently large to form a receiving reservoir for the liquor as it exudes.

From the pulque, by a process of distillation carried on in their pulquerias, the Mexicans manufacture a fiery and intoxicating liquor which they call "aguardiente de maguay," "mescal," or "mescal tequile," to distinguish it from "mescal sotol," made more cheaply from Dasylirion. Both pulque and mescal are regularly peddled in the streets in receptacles made of pig-skins, which will hold from twenty to thirty gallons. They may always be obtained in the pulquerias or cantinas (saloons), where the walls are

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* Amaryllideae, 174.

† Report of Sisal Hemp Culture. Fiber Investigations. 1891. 46.

covered with highly-colored representations of the "Sacred Heart,*" "the Good Shepherd," etc., to keep the mind from being inflamed with thoughts of strife and blood. A pinch of salt, or flavoring of orange or lemon peel, is usually taken with the mescal, to remove the fiery taste.

Considered from the stand-point of food, certain species of Agaves growing in our Southwestern States and Territories are esteemed great delicacies by the Indians. These do not have so great a flow of sap as the Maguay plants and are further distinguished from them by having shorter and relatively broader leaves. Several species are used, but they are quite indiscriminately called "Mescal," as is also the jelly-like mass prepared from them as well as the intoxicating liquor fermented and distilled from its juice.

The species most eagerly sought after by the Apaches are A. Palmeri, and A. applanata Parryi. Mr. Coville† gives a very interesting account of the use of even the small A. Utahensis by the Panamint Indians. The process of cooking seems to be much the same in all cases. A large pit is prepared and lined carefully with small smooth stones. A fire is kept up within the pit until the stones are thoroughly heated, and then raked out leaving the pit ready for use. The plants are trimmed until nothing is left except the hearts, which consist of the sweet juicy stalks and young leaves. These are heaped on the hot stones in the pit, covered over with grass and earth and left to steam for two or three days. By this time all except the fibrous tissue is reduced to a jelly-like mass, very palatable and nutritious. Captain Bourke‡ states that the Apaches put in the pit a plug made of the stalk of the plant. This they pull out as a test, and if the end of the plug is cooked the squaws decide that the whole mass is.

Dr. Parry writes in a letter to Dr. Engelmann, that this

* Captain J. G. Bourke. Folk Foods of Rio Grande Valley and Northern Mexico.

† Panamint Indians of California. American Anthropologist, v. 1892.

‡ On the Border with Crook. p. 200.

cooked "Mescal" is much like half-made molasses candy into which oakum has been dipped. Professor Toumey writes that it has a sweet and not disagreeable taste, but that it has a smoky flavor arising from the method of cooking.

By fermenting and distilling its juice the Indians make their drink called "Mescal," which is very intoxicating, casting all records attributed to "Jersey lightning," most completely in the shade. Professor Toumey writes a very interesting letter in regard to finding a party of Pepago Indians in May, 1894, encamped in the Catalina mountains, fourteen miles north of Tucson, for the purpose of making "Mescal" from A. Palmeri. He says the camp had a rank odor from the fermentation of the cooked mescal thrown about on all sides. On taking the mescal from the pit, it was put into large Indian baskets, and the women squatted down on the ground and stripped the epidermis and as many of the fibro-vascular bundles as possible from the cooked leaves. The prepared material was then spread on the ground or on blankets to dry. Large quantities of mescal are made by the Indians each spring, and carried back with them to their reservations, where it forms an important factor in their food supply throughout the year.

Dr. Havard* says that the mescal pits are still seen in the Guadalupe Mountains, Texas, and that "cooking develops a large proportion of grape sugar which exists in combination with citric acid as a citro-glucosid. It is set free by exposure to heat or by application of cold water." He also says that the young leaves yield by pressure a juice which "is slightly acidulous, laxative and diuretic, therefore a good antiscorbutic."

Professor Toumey's letter already referred to goes on to say that the epidermis and fibers, separated by the squaws from the edible portion of the mescal, are not thrown away, but are taken by the men, thoroughly washed and

* Proceedings U. S. National Museum. 1885, viii. 519.

cleansed, and the fibers well separated, so that they can be made into ropes. Each man takes a quantity of these fibers, and begins to twist. When the strands are of sufficient length, they are tied to trees, and the men backing away from the trees continue to add fibers and to twist. Their work is assisted by small sticks, about a foot long and larger and heavier at one end. By fastening the small end to the rope close to the hand, the twist made is given a greater force by the motion of the heavy end in flying round and round. When the ropes are of the required length, the loose ends are pegged to the ground and left for several days to dry. Professor Toumey writes that hundreds of these ropes were staked out in the camp that he visited.

Of the Agaves native to the United States, the A. Lechuguilla produces the well-known Ixtli, or Tampico fiber, renowned for its great strength and durability. The fiber is coarse and short, but very tough. It is used in Texas and Northern Mexico for making sacks to convey ore from the mines, for coarse ropes, brushes, etc. In extracting the fiber, the spines and horny margins are removed, the leaves are crushed or scraped with knives by hand, and then after one or two days' exposure to the sun, the soft connective tissue is washed out, and the fibers collected. Machinery is now being employed in some places for obtaining this fiber.

The patient and industrious Mayas early recognized the value of fibers for domestic purposes, and it can probably be proved that they made of fiber an article of export. From generation to generation the culture of the best fiber-producing species has been their chief industry, and it is to-day a never failing source of wealth to the peninsula of Yucatan. Their culture has developed several varieties. A. rigida elongata, called Sacci or Saqui, by the Indians, is their chief dependence. Its fiber is abundant, white and flexible.

Dr. Perrine, when American Consul to Campeachy,

strongly advocated* the introduction of tropical plants in Southern Florida. As a result of his patriotic and laborious efforts, a number of species were planted at Key West, and on the Perrine Grant, Biscayne Bay, in 1836, 1837, and succeeding years. The A. rigida sisalana, or Yaxci (pronounced Yaashki) has taken most kindly to its new home. It forms dense thickets in many places, and seems to have become fully naturalized below the frost line in Florida and the adjacent islands. There seems to be every reason for believing that the efforts now being made in Florida and the Bahamas in its cultivation, and in improving methods for the extraction of its fiber, may result in adding greatly to the wealth of both places. Its leaf produces less fiber than the Yucatan form, but it "excels in fineness, softness, flexibility and luster."

CLASSIFICATION AND STUDY OF SPECIES.

The genus Agave may be characterized as being acaulescent or shortly caulescent, having leaves in a close rosulate tuft, with broad clasping bases, usually fleshy, and more or less rigid, traversed by strong, elastic, longitudinal fibers, and generally armed with terminal and lateral spines; scape bracteate; inflorescence subspicate or paniculate; flowers articulated on short, persistent pedicels, bearing one or two bracts, usually brownish or greenish yellow, proterandrous; perianth narrowly funnel-shaped to campanulate, with six nearly equal oblong or linear segments; tube straight or somewhat curved; filaments filiform, folded in the bud, in the flower usually extending considerably beyond the segments; anthers large, versatile, introrse; ovary oblong to cylindrical; septal glands large, and in many species secreting a remarkable quantity of nectar; style at last usually equaling or exceeding the stamens, filiform, slightly clavate, with three commissural

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* Senate Document No. 300, March, 1838. Dr. Schott, Agricultural Report. 1869. 257.

stigmas, which slightly open or broadly expand at maturity; fruit a dry, erect, globose to cylindrical capsule, loculicidally three-celled, having two rows of numerous, thin, black seeds in each cell, and generally opening in upper part only; embryo filiform.

The inferior ovary* gives the strongest reason for classing this genus with the Amaryllidaceae. Its capsules, numerous discoid seeds, and elongated cotyledons show affinities with Liliaceae. Within the Amaryllidaceae, it is closely allied to Furcraeae.

The best basis for a classification of the Agaves lies in the fundamental differences in the forms of inflorescence, accompanied, as they are, by group differences in the structure and forms of the leaves. The sections recognized by Dr. Engelmann, — *Singuliflorae*, *Geminiflorae*, *Paniculatae*, may be very technically described as having flowers usually subspicate and solitary; flowers usually subspicate, in pairs; and flowers paniculate. As these are subgeneric

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* Leichtlinia protuberans Ross, A. protuberans Engelm., has been placed between the genera Polianthes and Agave, on account of its conical ovary protruding into the perianth.

On July 29th, I collected a monstrous inflorescence of A. applanata Parryi, in the mountains above Pleasant Valley, a few miles from Fort Bayard. The top of the scape had been broken by some accident, and the plant had made an effort to produce flowers on a low branch of the inflorescence. These flowers were in a thick mass close to the main axis. All were imperfect or distorted. Some were grown together. The segments in nearly all cases were greatly broadened and frequently thickened. The filaments also were broad and in some cases showed a distinct reversion to the petaloid character. In some flowers it was difficult to tell whether a certain organ represented a segment or a filament, but in the larger and better developed flowers, there was usually an equal number of each, and this number varied from six to five, four, three, and even two. In one large flower the style was irregularly four-lobed, and the stigma, three-lobed, one lobe being much larger than the other two. The ovary was usually represented by a short thick mass of tissue with little or no differentiation. Mr. Webber writes me of finding a monstrous Agave flower upon a plant of what I suppose was A. rigida sisalana. This flower had stamens and pistils perfectly developed, but was without any ovary differentiation, and was found growing from a cluster of leaves of the bulb.

distinctions, however, perhaps it is well to make use of the substantive names used by Mr. Baker for these divisions,— MANFREDA (Salisb.), LITTAEA (Tagl.), EUAGAVE (Baker), and also to use the terms employed by him to designate the groups formed on leaf characters, though so far as they apply to our United States species, I cannot follow him strictly in their application.

It must constantly be borne in mind that the variability of species within the genus is so great that any attempt to draw precise lines in classification results in failure. A. Lechuguilla has been found with flowers in clusters* of from three to ten instead of in pairs. Both with reference to leaf and floral characters, A. Utahensis might almost as well be grouped with Euagave as with Littaea. Some six or eight plants of A. brunnea Watson, of the Manfreda section, bloomed at the Garden last June. Most of these plants bore single flowers in the axils of their bracts. One plant of a vigorous growth, showed at two points a second flower in the axil of the lateral bractlet. One of these was sessile and the other pedicellate, as shown in plate 63, figs. 8, 9. Dr. Engelmann notes a case † in which a plant of A. Virginica produced secondary flowers year after year. In his plant a third flower sometimes appeared. In leaf characters many instances could be cited of departure from the normal form. A. parviflora of the group Filiferae has been considered unique in bearing teeth as well as filaments, but the Garden has recently received a specimen of A. Schottii from Professor Toumey which shows the same peculiarity.

I subjoin the general schemes of classification adopted by Terraciano and Baker.

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* Dr. Engelmann, Gard. Chron. Jan., 1883, 48.— A. heteracantha, Engelm.

† Collected Writings, 303.

TERRACIANO.

Conspectus sectionum ac subsectionum.

Agave.

I. Aplagave, Terr.
- A) Singuliflorae, Engelm.
  - a) Herbaceae, Terr.
  - b) Spicatae, Terr.
  - c) Canaliculatae, Terr.
- B) Geminiflorae, Engelm.
  - d) Emarginatae, Terr.
    - I.
      - 1. Yuccaefoliae, Baker.
      - 2. Striatae, Terr.
      - 3. Filiferae, Baker.
    - II.
      - 4. Attenuatae, Baker.
      - 5. Aloideae, Terr.
      - 6. Aculeatae, Terr.
  - e) Marginatae, Baker.

II. Cladagave, Terr.
- C) Paniculiflorae, Terr.
  - f) Americanae, Terr.
    - 7. Integrifoliae, Baker.
    - 8. Americanae, Baker.
    - 9. Rigidae, Terr.
    - 10. Viviparae, Baker.
  - g) Submarginatae, Baker.

BAKER.

Key to genera founded on inflorescence:—
- Euagave, Baker.
- Littaea (Tagl.).
- Manfreda (Salisb.).

Key to Series and Groups founded on the shape, size and texture of the leaves:—

Series I. Coriaceo-carnosae.
- Group 1. Filiferae.
- 2. Marginatae.
- 3. Submarginatae.
- 4. Americanae.
- 5. Rigidae.
- 6. Striatae.
- 7. Integrifoliae.

Series II. Carnoso-coriaceae.
Group 8. Geminiflorae.
9. Aloideae.
10. Serrulatae.
11. Attenuatae.

Series III. Flexiles.
Group 12. Viviparae.
13. Yuccaefoliae.

Series IV. Herbaceae.

SYNOPSIS OF UNITED STATES SPECIES.

* Acaulescent; perennial, from stout, evident, sometimes elongated rootstocks; roots fleshy; leaves loosely spreading or ascending, soft, thin, annual, without horny spines; flowers normally subspicate and solitary; stigmatic lobes spreading.— MANFREDA (Salisb.). *Herbaceae* (Baker); *Singuliflorae* (Engelm.).

+ Stamens inserted near base of tube; leaves usually green.

A. VIRGINICA L.— Leaves six to fifteen, green, sometimes marked with purple striae, very rarely spotted, 15 to 45 cm. long, 2 to 5 cm. wide, lanceolate to oblong or spatulate, concave, a little flexuous; apex ending in a sharply narrowed herbaceous point; margin irregularly and obscurely serrate; scape slender, 9 to 18 dm. long, upper 3 to 5 dm. or more floriferous; lowest bracts almost as long as the leaves, upper ones much narrower and shorter; flowers shortly pedicelled, greenish or brownish yellow, very fragrant, 25 to 37 mm. long; ovary oblong; tube narrowly funnel-shaped; segments linear-oblong, 10 to 12 mm. long; filaments much thickened upwards, and extending 20 to 25 mm. beyond segments; anthers 12 mm. long; capsule globose, 15 to 20 mm. long, including short stipe and beak, and nearly as wide; seeds 4 to 6 mm. in longest diameter. — Sp. Pl. (1753) 323; Jacobi, Monogr. (1864) 174; Engelm. Trans. St. Louis Acad. iii. (1875) 301, Collected Writings, 306; Terr. Monogr. (1885) 13; Baker, Handbook of the Amaryllideae, (1888) 197. — Icones: Bot. Mag. ser. 1, xxix. pl. 1157; Jacquin, Icones Plant-

arum, ii. pl. 378; Lamarck, Encyclop. Method. i. pl. 235, fig. 2.— Maryland southward to Florida, westward to Indiana, Tennessee, Missouri and Texas. Mr. Nealley reports it as abundant around Corpus Christi, Texas.— Plates 26 and 27.

Var. TIGRINA Engelm.— Stout, with large purple-spotted leaves, and depressed globose capsules.— Trans. St. Louis Acad. iii. 302, Collected Writings, 306.— Bluffton, South Carolina, Dr. Mellichamp. In one spot only, — a tongue of partly brackish land, extending out into the salt mud and marsh under dwarfed live oaks, cassine and saw palmetto, on the decayed shells mixed with sand and earth of what appears to be an Indian oyster-heap.* This form, discovered by Dr. Mellichamp twenty years ago, still persists in the locality indicated. Plants sent to the Garden by Dr. Mellichamp early last spring began to send up new leaves very soon. These were green at first but began to develop purple spots in May. Plate 63, Fig. 1, shows the plant in its early growth.

Dr. Engelmann† mentions a plant which year after year produced second and sometimes third flowers on the pedicels. In the Engelmann and Gray herbaria there are specimens of a monstrous form sent by Dr. Short from the bank of Kentucky River near Elk Lick in 1831, 1833, and 1834. These plants have very large broad leaves; their flowers are thick and enlarged, with nearly cylindrical tubes, and their enlarged filaments cohere slightly by the edges, giving the effect of another much elongated tube. Flowers collected by Mr. Bush in Shannon County, Missouri, have filaments bent forward and even a little twisted at base.

The fragrance of the flowers is very persistent and was observed by Miss Johnson while making the plate from

* Dr. Mellichamp, in letter to Dr. Engelmann, Jan. 22d, 1876.

† Trans. St. Louis Acad. iii. 296. Coll. Writings, 303.

herbarium material. The name Rattlesnake Master is applied to this plant.

+ + Stamens inserted in upper part of tube; leaves usually spotted; Texan.

++ Stigmatic lobes rounded.

A. VARIEGATA Jacobi.— Leaves lanceolate, green, spotted with brown; teeth obscure but sharper than those of A. Virginica, and turned upwards; scape 9 to 15 dm. long, laxly flowered; flowers 38 mm. long; lobes about equal to tube; stamens inserted at two-thirds or three-fourths of the distance up the tube, 5 cm. long; anthers 8 mm. long; capsule oblong-cuspidate, 15 to 22 mm. long; seeds oblique.— Monogr. (1864) 180; Engelm. Trans. St. Louis Acad. iii. 303, Collected Writings, 306.— Lower Rio Grande, near Mier and Metamoras, Dr. J. Gregg, May, 1847.

++ ++ Stigmatic lobes emarginate.

A. MACULATA Regel?—Leaves fleshy, recurved, concave or channeled throughout their entire length, 15 to 30 cm. long, 10 to 20 mm. wide, narrowly lanceolate, tapering to apex, light green, glaucous, mostly spotted with dark green or brown; margin usually transparent, with evident, irregular, small cartilaginous teeth; scape 9 to 20 dm. high, the upper 2 or 3 dm. floriferous; bracts ovate to linear-lanceolate at base of scape, and more or less denticulate, the upper ones gradually reduced, entire; flowers nearly sessile, purplish-green to white, fragrant, 30 to 50 mm. long; segments suberect and mostly nearly as long as the stamens, or less commonly widely recurving, oblong, 10 to 18 mm. long, 5 mm. wide; filaments inserted at base of lobes; anthers 8 to 16 mm. long; stigma velvety at tip; capsule 20 to 25 mm. long, including stipe and beak, a little longer than broad, its walls thicker than in A. Virginica.— Ind. Sem. Hort. Petrop. 1856, 16, Annot. Bot., Ann. des Sci. Nat. vii. (1856) 74, Gartenflora,

1857, 158; Baker, Amaryllideae, 196; Terr. Monogr. 11; Engelm. Bot. Mex. Bound. (1858), 214. *A. maculosa* Engelm. Trans. St. Louis Acad. iii. 301, Coll. Writings, 305. — Icones: Hook. Bot. Mag. ser. 3, xv. pl. 5122; Fenzi, Gard. Chron. 1872, 1194, fig. 273. — Southern Texas. — Plate 28.

Represented by two forms, of like distribution, of which the more common has the perianth tube longer than the suberect segments which nearly conceal the anthers; the bracts are elongated, and the leaves long, robust and slightly denticulate. The other form, which is the variety *brevituba* of Engelmann, Trans. St. Louis Acad. iii. (1875) 301, Coll. Writings, 305, has the tube about equal to the segments, which are frequently recurved. This exposes the longer anthers and filaments. The bracts are broader and shorter, and the leaves are short and narrow.

This is an exceedingly variable species. I have placed in it all specimens of the Manfreda group in Southern Texas which have emarginate lobes to the stigma. I have followed Baker in employing for it Regel's name, although the emargination of the stigma is not mentioned in the original description of A. maculata. The filaments are there described as being long-exserted, and the species is said by Regel to be related to A. rubescens, Salm-Dyck. In the figure of Hooker cited, the emargination of the stigmatic lobes is scarcely more than suggested, but in that of Fenzi, it corresponds well with the typical form of our species. I find a specimen in the Gray herbarium, collected by Dr. Palmer, with narrow strongly denticulate leaves; flowers 35 mm. long, segments 10 to 12 mm. long, and filaments 15 to 25 mm. long. These filaments protrude beyond the segments. The stigmatic lobes are emarginate in some of the flowers. It is possible that collectors will find Regel's plant, and perhaps transitions between the two, in Northern Mexico. Perhaps our plant may prove to be a variety of the other.

Specimens examined:— Mier, amongst Mezquit trees,

Dr. Wislizenus, No. 373, May 31, 1847; Cultivated at Missouri Botanical Garden, July, 1861; July, 1879; Otto Ludwig, San Antonio, 1877; Dr. V. Havard, Eagle Pass, 1883; Albert Turpe, 1893; A. A. Heller, June, 1894, Corpus Christi; Dr. Schott, Rio Bravo del Norte, Lizard Hills, April, 1854, somewhat intermediate in form.—Var. *brevituba*:—Wright, No. 1905, below El Paso; G. C. Nealley, 1887, 1895; with protruding filaments, Dr. Edward Palmer, 105 miles southeast of San Antonio, September, 1879, No. 1306.

Dr. Schott in a note, April, 1854, states that the leaves of A. maculata are recommended by the Mexicans as an efficient remedy against the bites of rattlesnakes. Mr. A. A. Heller makes a very similar statement.

* * Acaulescent; perennial, from scarcely distinguishable rootstock; roots fibrous, fleshy; leaves ascending, turned to one side, relatively narrow, thick, fleshy, fibrous, persistent; end-spine horny; flowers normally in pairs, forming a dense subspicate inflorescence.— LITTAEA (Tagl.). *Geminiflorae* (Engelm.).

+ Leaf with a filiferous margin; marked with white lines made by delicate layers of epidermis left by margins of adjoining leaves in separating from the bud.— FILIFERAE (Baker).

++ Marginal fibers delicate.

A. SCHOTTII Engelm.— Leaves 15 to 35 cm. long, 6 to 12 mm. broad, convex on lower side; end-spine 6 to 10 mm. long, slender, terete, brownish-gray; margin of base membranous, sometimes (in variety) serrulate; scape 15 to 20 dm. high; bracts very slender; flowers pale yellow with agreeable fragrance; 30 to 40 mm. long; perianth infundibular; lobes linear to oblong, or short and broad; filaments inserted a little above the middle of the tube; anthers 7 to 12 mm. long; ovary broad; capsules nearly globular or oblong, 10 to 15 or 25 mm. long, including stipe.— Trans. St. Louis Acad. iii. 305, Collected Writings, 307; Baker, Handbook of the Amaryllideae, 166. *A. geminiflora* var. *Sonorae* Torrey, Bot. of the Boundary (1858), 214. *A. geminiflora* var. *filifera* Terr. Monogr.

18.—Very abundant on the mountains of Southern Arizona, from the Santa Catalina to the Chuncahus at an elevation of about 5,000 feet. — Plate 29.

Specimens examined: — Dr. A. Schott's original specimens from Sierra del pajarito, VII., 1855; No. 1433 of Emory's Expedition, 1873; J. G. Lemmon and wife, April and May, 1880 and 1881; C. G. Pringle, Southern Mountains, 1881; Rincon Mountains, June, 1884; Santa Catalina Mountains, 1882; J. W. Toumey, Santa Catalina and Rincon Mountains, 1894.

Var. SERRULATA.— Of distinctly smaller habit; leaves narrower and shorter; leaf bases narrower, serrulate and slightly undulate; end-spine shorter; inflorescence more compact; perianth apparently broader at base; lobes very short and broad; anthers much smaller; filaments inserted at a greater distance below segments, longer; lobes of stigma fringed; capsules smaller, thinner, more persistent.— Collected in the Rincon Mountains, July, 1894, by Professor J. W. Toumey, of the University of Arizona, who states that he finds it to occur further south than the typical form.— Plate 29.

A specimen of A. Schottii collected by Mr. Pringle on "dry, rocky slopes of Southern Mountains," 1880, has capsules with much elongated beaks. Another specimen of Mr. Pringle's from the Rincon Mountains, June 19th, 1884, has groups of three and four flowers in the axils of the bracts.

Professor Tourmey writes that this species so thickly covers large areas miles in extent on the southern slope of the Santa Catalina Mountains that it is almost impossible to travel over it. The variety is not found in this locality. This plant is the amole of Arizona, and is sold by Mexicans and Indians in the streets of Tucson (Professor Toumey).

++ ++ Marginal fibers short and stout.

A. PARVIFLORA Torrey.— Plants very small, forming low rosettes; leaves thick, 5 to 10 cm. long, 1 cm. wide,

linear-lanceolate from a broad, deltoid base; end-spine slender, terete; marginal fibers few; base of leaf bordered with minute, cartilaginous teeth; scape 12 to 15 dm. high, slender; bracts very narrow with a broad base; flowers in twos or fours, small, 12 mm. long; perianth 8 mm. long; filaments inserted in lower part of tube, a little longer than perianth; capsule globular or ovoid, more or less cuspidate, 9 to 12 mm. long, 9 to 10 mm. broad; seeds dull, 2.5 mm. wide. Professor Toumey found well-developed seeds on August 20th.— Botany of Mexican Boundary (1858), 214; Engelm. Trans. St. Louis Acad. iii. 306, Collected Writings, 307; Terr. Monogr. 18; Baker, Amaryllideae, 166. Dr. Trelease in Fifth Report of the Garden, page 164, speaks of the rediscovery of this interesting plant by Professor Toumey in the Pinal Mountains, and makes critical notes in comparison. His plate is reproduced for this paper by his permission.— Mountains of Arizona, at head waters of the Salt and Gila Rivers, in the Pinal Mountains, at an elevation of about 7,000 feet (Professor J. W. Toumey), and near Chihuahua, Mexico.— Plate 30.

Specimens examined: — Original Schott specimens in Engelmann, Torrey and National herbaria, from Sierras of Pimeria alta, Arizona, July, 1855; J. W. Toumey, July, 1893; also specimens in Engelmann, Gray and Columbia College herbaria from "dry, porphyritic hills," near Chihuahua, found by Mr. C. G. Pringle in fruit, September 6, 1888. These Mexican specimens have longer and slightly narrower leaves, but agreeing with the Toumey specimen in being concave on the upper side. Their flowers are much longer than those from Arizona. The capsules are conically pointed above, and their globular form is similar to that of the Schott specimens.

Professor Toumey writes that A. parviflora propagates profusely by numerous suckers. Seeds from his capsules have developed into plants 5 cm. high, and from 8 to 10 cm. in diameter. Their pretty little rosettes bear dark green leaves with reddish-brown end-spines. After loosening

from the central bud, an extremely delicate white margin soon fluffs away, and the new epidermis below bears tiny little teeth from apex to base. A further development results in the formation of marginal threads on the upper portion of leaf, which eventually split off, while the teeth persist on the thin membranous margin of the base.

+ + Leaf with a continuous, toothed, horny margin from apex to base.— MARGINATAE (Baker).

A. LECHUGUILLA Torrey.— Leaves about 10 to 15, thick, concave above, rounded below, usually 20 to 35 cm. long, 2 to 3.5 cm. wide, others much larger, 5 cm. wide and sometimes 60 cm. long, narrowed above a very broad base, and after widening slightly, maintaining nearly parallel edges for some distance, and gradually tapering above, deep green with many interrupted darker lines on lower side, and less distinct ones on upper side when young; end-spine channeled, 18 to 40 mm. long, extending downwards to a point on the back of leaf; margin rather broad; teeth commencing at a considerable distance below apex, largest towards middle of leaf, 5 to 10 mm. long, rather distant, stout, usually strongly reflexed, sometimes flexuous; color of end-spine, margin and prickles, brown, soon turning to gray; margin and prickles at last splitting off, and falling away in pieces or entirely, but usually leaving a part attached to end-spine; scape slender, 18 to 40 dm. high; bracts 50 mm. long below, 10 to 12 mm. above, deciduous; flowers sometimes in clusters of three to several, and variable in size, (fresh) from 30 to 40 mm. long above base of ovary; perianth spreading, campanulate, greenish or yellowish white, sometimes deeply tinged partly or completely with purple; tube 2 to 3 mm., lobes 15 to 18 mm. long; filaments purple, inserted at base of lobes, 35 mm. long; anthers 13 to 16 mm. long; style slightly shorter than filaments; capsules ovoid or oblong, 15 to 35 mm. long; seeds smooth, shining, 3 to 4 mm. in longest diameter.— Bot. of the Boundary (1858), 213. *A. heter-*

acantha Zucc. Acta Acad. Leop.-Carol. xvi. 675; Engelm. Trans. St. Louis Acad. iii. 306, Collected Writings, 308; Baker, Amaryllideae, 168. *A. Poselgerii* Terr. Monogr. 32.— Abundant on the limestone highlands of West Texas, and along the Rio Grande, as far east as Presidio, extending into Mexico and New Mexico. Mr. Nealley reports the Devil's river as the eastern limit.— Plate 31.— By error, the specific name was originally printed *Lecheguilla.*

Specimens examined:— From Mr. C. Wright, Nos. 1907 (1851), 682 (1849), 1432 (1852), Mexican Boundary Survey; Dr. E. Palmer, 1878; O. Meusebach, Jan., 1880; Dr. V. Havard, June and Sept., 1880, 1881, Guadalupe Mts., El Paso, and Presidio; J. G. Lemmon, Organ Mts., May 18, 1851; G. R. Vasey, El Paso, 1880, 1881; Shaw's Garden, July, 1884; W. A. Evans, El Paso, June, 1891; Lieut. Emory's Second Mex. Bound. Survey, 213.

The flowers I observed in Texas did not open their anthers upon first expanding. The anthers were of a salmon tint which marked a contrast with the lower ones a day older, which showed a bright yellow coloring, caused by the dehiscence of the cells, and discharge of the pollen. I saw many plants in Texas showing a tendency towards a paniculate inflorescence, and Dr. Engelmann in Gard. Chron. June, 1883, gives a special description of specimens collected by Dr. Havard. A figure is given showing a cluster of ten capsules.

A pest of the arid mesas and limestone cliffs of West Texas. The parenchyma of leaves and root furnish large quantities of amole valuable for cleansing purposes.* Its fiber, called Tampico, Ixtle, or Ystle, is very valuable† where strength and durability are required.

Though this plant certainly shows affinities with A. heteracantha Zucc. and A. Poselgerii Salm-Dyck, it differs from them in having a more stiffly sub-erect and one-sided

* Dr. Havard. Proceedings of U. S. National Museum, 1885, 518. Page 59 of this paper.

† Dr. Parry, Bot. of Bound. 11; Dr. Havard, l. c.; Kew Bull. Dec., 1887. Page 63 of this paper.

habit and in never developing a broad pale band down the face of the leaf. The group to which all these and a number of related forms belong, should receive careful study and comparison. Our plant may prove to be a variety.

+++Leaf with a toothed, horny margin, decurrent for some distance below end-spine. — SUBMARGINATAE (Baker).

A. UTAHENSIS Engelm.— Suberect, compact; leaves linear-lanceolate, concave, rigid, fleshy, glaucous, 12 to 17 cm. long, 2 to 2.5 cm. wide, or larger, not contracted above the broad base; terminal spine 20 to 35 cm. long, stout, channeled, gray, with brown base, slightly decurrent; margin sometimes repand; prickles 1.5 to 2 mm. long, deltoid above, very minute and close-set below; scape 15 to 24 dm. high, straight or flexuous; upper 3 to 6 dm. floriferous; panicle narrow; bracts very slender; pedicels once or twice forked; flowers in 2's or 4's, sometimes in 6's, 22 to 25 mm. long, yellow, with a very pungent and fragrant odor; perianth about as long as ovary, lobes cut nearly to its base; filaments inserted a little below the middle of the broadly funnel-shaped tube, 15 to 18 mm. long; capsules ovoid, cuspidate, 2 to 3 cm. long above the stipe, which measures about 4 mm.; seeds 4 mm. in greatest diameter, marked with flat punctate areoles.— Sereno Watson's Botany of 40th Parallel (1871), 497; Trans. St. Louis Acad. iii. 308, Collected Writings, 308; Baker, Amaryllideae, 177. *A. Haynaldi* Tod. var. *Utahensis* Terr. Monogr. 28.— Figured in "Garden and Forest," 1895, 385.— Along Virgen River in Beaver Dam Mts., Utah, as far north as Silver Reef, 4,000 to 6,000 ft. altitude; Northern Arizona, south of the Kaibab plateau, west to Ivanpah and Resting Springs, California, and east to Charleston Mts., Nevada. Abundant throughout Northern Arizona on the Colorado plateau, the rocks in the Grand Cañon being covered with the plants.— Plate 32.

Specimens examined: — Utah; Dr. Palmer, St. George, 1870, one with leaves very repand, 1877. Arizona;

Bischoff, 1871; Thompson, 1872; Mrs. A. P. Thompson, Kanab, 1872; J. G. Lemmon, Peach Springs, June, 1884, flowers in 6's with rudiments of two more; H. H. Rusby, Peach Springs, 1883, scape flexuous at nodes; J. W. Toumey, Grand Cañon, 1894. Nevada; Coville and Funston, Charleston Mts., March 6, 1891. California; Plant cultivated by S. B. Parish, San Bernardino, from seed obtained at Ivanpah, Cal. The leaves from this plant are very short, and have teeth set on a very prominent fleshy base, end-spines are much elongated, one measuring 5.5 cm. A very dwarf specimen, smaller than A. parviflora, is in the Engelmann herbarium. It was collected by Dr. Palmer, at St. George, Utah, May, 1877. Its leaves are very narrow, and much turned to one side, 4 to 6 cm. long; scape very slender, with small, narrow bracts. In the same herbarium are a few thick leaves, labeled Palmer, 1877, 12 to 36 cm. long, slightly one-sided, contracted to a narrow base, acuminate at apex, with brown end-spines 4 cm. long.

A. Utahensis is the most northern species of Agave, excepting A. Virginica, one of the Manfreda section. It was recommended in England as perfectly hardy, but Mr. J. Wood states that he has not found it so.* It is the Mescal plant of the Piutes and Panamint Indians.

Here, in my judgment, should be placed A. Newberryi Engelm. The only specimens in our herbaria are small fragments of an inflorescence, and a single leaf in the herbaria of the United States Department of Agriculture, and in the Engelmann collection. The leaf is very narrow and probably had an entire margin, but I observe a few breaks in the epidermis where possibly short teeth may have separated.† The end spine is broken off; the pedicels are long, and suggest branching and a paniculate inflorescence, but I strongly suspect the plant to be a monstrous form of A. Utahensis, which species so frequently approaches the

* The Garden, xxxiii. 310.

† Engelm. Trans. St. Louis Acad. iii. 309, Collected Writings, 309.

paniculate character, that it might be placed in the Euagave section with almost as great propriety as in that of Littaea. The flowers seem identical with those of A. Utahensis. I subjoin a description, that the plant may be looked for.

A. Newberryi Engelm.— Leaves rigid, ensiform, about 20 cm. long, 2 cm. wide; end-spine dark-colored, 12 mm. long, grooved (Engelm.); margin probably entire; scape 24 dm. high, with lanceolate bracts 12 mm. long, and a loose elongated sub-paniculate inflorescence; contracted branches 8 mm. apart, 12 mm. long; perianth nearly equal to ovary; tube short, broad; stamens inserted near the base of tube, short. — l. c.: Baker, Amaryllideae, 186; Terr. Monogr. 36. — Peach Springs, Northwest Arizona, Dr. J. S. Newberry, March, 1848, altitude 4,000 feet.

* * * Mostly acaulescent in our species, root stocks and roots as in last group; leaves rosulate, marked with impressions of adjoining leaves, sometimes a little turned to one side, stout, fleshy, fibrous, persistent, with stout, horny end-spines; inflorescence paniculate, with clusters of flowers at ends of branches.— EUAGAVE (Baker). *Paniculatae* (Engelm.); *Cladagave, Paniculiflorae* (Terr.).

+ Leaf with a horny margin which usually includes at least the upper teeth, and sometimes extends nearly or quite to base. — SUBMARGINATAE (Baker).

++ Stamens inserted in upper part of tube.

= Leaves very thick, fleshy, spreading. California.

A. DESERTI Engelm.—Leaves densely clustered, upper ones ascending, lower ones spreading, narrowed at a considerable distance above the base, broadest above the middle, and slenderly acuminate at apex, 30 to 50 cm. long, 5.5 to 6.5 cm. wide; end-spine 3 to 4 cm. long, slender, channeled, grayish with brown tip, very shortly decurrent; teeth stout, gray, 12 to 20 mm. apart, 3 to 4 mm. long, lanceolate-deltoid and recurved above, and minute, close-set, and turned upward below; scape 12 to 30 or even 60 dm. high; bracts close-set below, large, triangular, acuminate, clasping, appressed, dentate, and terminating in a slender black spine 12 to 18 mm. long; branches transversely flattened; flowers 50 to 55 mm. long; perianth yellow, about same length as ovary; segments oblong; filaments inserted at base of segments, and twice their

length; capsules oblong, 35 mm. long, shortly stipitate, cuspidate. Nectar abundant, descending in a shower when scape is shaken (Parish).— Trans. St. Louis Acad. iii. 310, Collected Writings, 309; Terr. Monogr. 49; Baker, Amaryllideae, 178.—From Palm Springs, California, along the eastern slope of the San Jacinto Mountains into Lower California, at altitudes of from 2,500 to 3,000 feet.—Plates 33 and 34.

Specimens examined:— From Emory's Expedition, Nov. 29th, 1846. Torrey Herb.; Dr. Palmer, East of San Felipe, 1875; Geo. N. Hitchcock, East of San Felipe, 1875; G. R. Vasey, Mountain Springs, 1880; S. B. Parish, Mountain Springs, 1880; Parish Brothers, San Felipe, 1882.

Very abundant where found. Miss Johnson has drawn the plate figured, from the original sketch made by Mr. Stanley on the Emory Expedition, Nov. 29th, 1846. The sketch is deposited in the Torrey Herbarium, Columbia College, and was kindly loaned by Dr. Britton, who also gives permission to have it reproduced here.

Lieut. Emory writes* on his discovery of this plant, Nov. 29, 1846: —"We rode for miles through thickets of the centennial plant, and found one in full bloom. The sharp thorns terminating every leaf, were a great annoyance to our dismounted and weary men, whose legs were now almost bare. A number of these plants were cut by the soldiers, and the body of them used for food."

= = Leaves closely imbricated, and somewhat appressed; mature plant usually globose.

A. APPLANATA Lemaire.— Leaves crowded upon a short axis, making a contracted, very symmetrical rosette, which may bear over a hundred leaves, and have a height nearly equal to the diameter; younger leaves ascending, more or less acute or acuminate, or with their upper margins

* Notes on a Military Reconnoissance. Washington (1848). 104.

curved inward with an acuminate effect, lower ones spreading, broader, scarcely or slightly tapering at apex; leaves oblong-lanceolate to spatulate or broadly ovate, 25 to 40 or 60 cm. long, 8 to 17 or 25 cm. broad, 25 to 40 mm. or more thick at cushion above base, rigid, thick, slightly narrowed above the broad clasping base, convex on lower side, flat on upper side in lower half, and concave in upper half, color from cinereous, glaucous, blue-green to grass-green; terminal spine stout, 15 to 25 mm. long, sometimes much longer, purplish-black or brown, often grayish in age, flattened and channeled above; horny margin purplish or brown turning gray, more or less decurrent, sometimes extending to base of leaf; prickles 1 to 2 cm. apart, the lower ones gradually smaller, more close-set and deflexed; scape stout, 25 to 50 dm. (or even 9 to 12 m.) high, bearing numerous large herbaceous bracts, which taper very narrowly and end in a sharp point; panicle a meter or more long, one-third as wide in the middle; branches horizontal or somewhat ascending, stout, flattened horizontally; flowers campanulate spreading, yellow or greenish or brownish-yellow, crowded on short pedicels, 35 to 60 mm. long; segments 15 to 21 mm. long; filaments inserted a very little below cutting of lobes, 35 to 42 mm. long; anthers 14 to 15 mm. long; capsules stout and broad, 3 to 5 cm. long, about half as broad. Nectar abundant. Fragrance pleasant. Propagation by offsets and suckers.

A. applanata is described as a Mexican species. So far as I have been able to ascertain, Dr. Trelease is the only one who has alluded to it as occurring within our borders.* A species in the mountains of Western Texas is apparently the same as the form common in European and American greenhouses under this name. The Texan plant is variable, but many specimens show a resemblance to Dr. Engelmann's A. Parryi which indicates a close relationship. There also seem to be many grades intermediate between

* Report of Missouri Botanical Garden, iv. 191.

Pringle's type specimens of A. Huachucensis Baker, and the Rothrock specimens upon which Dr. Engelmann founded his description of A. Parryi. I have, therefore, though with considerable hesitation and reluctance, provisionally brought the three forms together as one species. I have felt obliged to call it A. applanata (though I have not been able to examine the European type specimens), as that is the oldest name. The Mexican type is described as having leaves more narrowed above the base than we find to be the case in the proportions of ours in mature plants. Mr. Baker describes it as having leaves 8 to 12 inches long, 3 to $3\frac{1}{2}$ inches broad at the middle, narrowed to 2 to $2\frac{1}{2}$ inches above the base; flowers greenish-yellow, $2\frac{1}{2}$ to 3 inches long. At the time of my visit to Texas the flowering season was practically over, and I was only fortunate enough to secure a very few retarded flowers, which were yellow and smaller than Baker describes. The herbarium material from Texas is very scanty and consists of a set of leaves labeled A. Wislizeni, accompanied by a very few flowers and capsules, in the Engelmann Herbarium. These were collected by Dr. Havard in the Guadalupe Mountains, October, 1881, possibly with the purpose of showing variations in the forms of leaves. The flowers in this set are much larger than the ones I saw. They have their filaments inserted at or a little above the middle of the tube. If there is no mistake as to the localities in which they were found, it seems to indicate that there is another form which I have not been able to separate by leaf characters. I hope it may be looked for. Similar flowers were collected by C. Wright in New Mexico in 1851 and 1852 (his number 1906). These flowers are not accompanied by leaves. Comparisons should be made with A. Wislizeni, which has a similar insertion of stamens. A. Wislizeni has been credited to Texas by Dr. Engelmann in his manuscript notes, by Dr. Coulter in the Botany of Western Texas, and by Dr. Havard.

The Texas plant is less compact than the other forms; its leaves are very rigid, oblong or spatulate, with a more or less acute, sometimes very acuminate apex, 18 to 30 cm. long, 9 to 12 cm. wide, bluish-green, cinereous, very glaucous; end-spine stout, 30 to 45 mm. long, purplish or reddish-black; horny margin of same color, occasionally traceable as a narrow line extending to base; prickles prominent, large, lanceolate, 7 to 9 mm. long, turned forward and upward; scape 25 to 50 dm. high, branches often ascending, flowers (fresh) 35 to 44 mm. from base of ovary to tips of lobes; ovary 18 to 23 mm. long; tube 2 to 3 mm. long; lobes 15 to 16 mm. long; filaments 35 mm.; anthers 14 mm. long. Style at length slightly exceeding filaments. Perianth, filaments, anthers, styles and stigmas yellow, ovaries green or greenish-yellow. Odor pleasant, not especially strong. Blooms in May and early June.— Lemaire, ex Jacobi, in Hamb. Gartenz. xx. (1864) 550. — Western Texas in Chenate region, Chisos, Guadalupe and Sierra Blanca Mountains, to Fort Davis.— Plate 35. The end-spines are sometimes much elongated. A plant was observed at Sierra Blanca upon which they measured from three to four inches. The few flowers which came under my observation were small and of a bright yellow color. Dr. Havard states that the glaucous leaved form of Agave served the Indians for Mescal, and that the pits for cooking it are to be seen in the Guadalupe mountains. At the Columbian Exposition this plant was labeled A. Parryi. In Dr. Coulter's Texan Botany A. Parryi is included in the flora. The plant is certainly not the one figured by Todaro in Hort. Bot. Panormitanus as A. applanata, but his figure does not correspond with Jacobi's description, nor represent the plant commonly cultivated under that name.

Var. Parryi. Mature plant more compact, globose, large, many specimens measuring from one to one and a half meters in diameter, and having a central pyramidal

bud 15 to 18 cm. in diameter at base, and 25 to 27 cm. high; leaves less rigid, more appressed, proportionally broader, and with much less acumination, from 30 to 38 cm. long above insertion, 10 to 14 cm. wide, often 4 cm. thick at cushion above base, broadest above the middle, color less tinged with blue, less glaucous; end-spine brown, 22 to 25 mm. long; marginal prickles brown, shorter, 3 to 5 mm. long, deltoid-lanceolate, deflexed or straight, very small at base; scape 25 to 50 dm. or more high, very stout, panicle occupying its upper half, both it and its horizontal branches red towards the sun; flowers much larger, 50 to 60 mm. long, tube 8 mm.; segments 20 to 21 mm. long; filaments two to three times the length of segments; capsule stout and broad, 3 to 5 cm. long, about half as broad; seeds 8 mm. in longest diameter. Blooms in June and early July, matures fruit in September. Propagates by offsets and suckers. Nectar is very abundant, descending in a shower when scape is lightly shaken (Dr. E. L. Greene).— *A. Parryi* Engelmann. Trans. St. Louis Acad. iii. 311, Collected Writings, 310; Terr. Monogr. 42; Baker, Amaryllideae, 175. *A. Americana* β. *latifolia* Torrey, Bot. of Bound. 213. *A. Mescal* Koch in Wochenschrift, 1865, 94. *A. crenata* Jacobi, Monogr. 229.— Southern New Mexico to Central Arizona. Mountains. Plates 36–39.

Specimens examined:—From Arizona, seeds, 1867, Dr. Parry; Bischoff, Wheeler's Expedition, 1871; Dr. Rothrock, No. 274, "Mescal," Rocky Cañon, 6,000 feet, July, 1874, Expedition and Survey of 100th Meridian, Engelmann's type plant, figured in Plate 37. New Mexico, Copper Mines, E. H. Emory, October 19th, 1846, (a colored drawing of this plant, made by Mr. Stanley, in the Torrey Herbarium, Columbia College); Dr. A. M. Bertholet, October, 1877; E. L. Greene, Silver City, June and October, 1880; H. H. Rusby, Bear Mts., 1881.

This plant was discovered by Lieut. Emory, October 18, 1846, near the Copper Mines, Santa Rita Mts., New

Mexico, on his famous trip to California. He states * that "the Apaches make molasses of the plant, and cook it with horse meat." Both Dr. Parry and Dr. Palmer also state that it is the plant used by Indians of the 35th Parallel for making "Mescal," but Dr. Wilcox asserts that the A. Palmeri is the only species used in Arizona for that purpose, and also that the cattle will only nibble the A. Parryi but that they eat the A. Palmeri.

The plant described as blooming at the Missouri Botanical Garden † and reported to have been sent from Arizona immediately previous to sending up its scape, was photographed here at the time, and plate 42 is reproduced from the original. A comparison with the illustrations in the Gardener's Chronicle, in Engelmann's Collected Writings, and the Agricultural Report for 1891, 358, plate vi., will show that the artist, unfortunately, in some way received a wrong impression of the extent of the decurrent leaf margins. The leaves of this plant are narrower, glaucous, spreading, with purplish tips, margin and prickles. The flowers are considerably smaller than the Rothrock type specimens, and the whole plant is very similar to the Texan form.— Plates 42 and 43.

Var. Huachucensis.— With same compact globose form, grass green, outer leaves very broad, often 25 cm. wide, and exceptionally 37 cm. (Dr. Wilcox), seldom over 65 cm. long; end-spine very stout, 25 mm. long, brown; marginal prickles brown, lanceolate-deltoid, deflexed, 8 to 12 mm. long; scape very stout; flowers yellow, 55 to 60 mm. long; tube 8 to 12 mm. long; segments 18 to 21 mm. long; stamens two to three times as long as segments. Blooms in middle of July and matures fruit in September. Propagates by offsets and suckers.— *A. Huachucensis* Baker, Amaryllideae, 172.— Found in

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* Notes on a Military Reconnoissance. Washington (1848). 104.

† Engelm. Gard. Chron., Aug., 1879; Collected Writings, 321.

Huachuca Mountains, Arizona, from an elevation of 5,000 feet to the top of the mountains.— Plates 40 and 41. Professor Toumey states that the plants often have a purplish cast which extends even to the flowers.

Specimens examined: —From J. G. Lemmon, September, 1883; C. G. Pringle, June, 1884, 5,000 to 8,000 feet; Dr. T. E. Wilcox, 1893; Professor J. W. Toumey, July 17, 1894.

++ ++ Stamens inserted near the middle of tube.

= Leaves relatively broad and short, deep-green, not glaucous; plant caulescent, globose. California.

A. Shawii Engelm.— Shortly caulescent, growing in large, dense rosettes from 5 to nearly 10 dm. in diameter, and, including the trunk, of about the same height; trunk 20 to 30 cm. long, clothed with the bases of the old leaves; leaves oblong-spatulate, acuminate, 25 to 40 cm. long, 8 to 12 cm. wide, 5.5 cm. thick at the cushion-like lower portion, broadest above the middle, deeply concave with narrowly acuminate effect in upper portion of young leaves; end-spine stout, 30 to 35 mm. long, channeled above, rounded below; margin broad, decurrent nearly or quite to base; prickles largest at middle of leaf, 6 to 15 mm. long, lanceolate, deltoid, close-set, generally turning outward and upward; color of end-spine, margin and prickles creamy white with a light salmon tint, changing successively to yellow, salmon, red, brown and gray as the leaves are maturing; margin and prickles sometimes become detached as in A. Lechuguilla; scape 24 to 36 dm. high, 50 to 65 cm. thick, nearly covered with leafy, appressed, deltoid-acuminate bracts 8 to 15 cm. long, with brown scarious margins and spiny tips; branches of panicle flattened, 10 to 22 cm. long, longest ones towards the middle, all subtended by large spreading bracts; flowers sessile at ends of branches in large compact clusters of 20 to 30, surrounded by thick, leafy bracts; flowers 75 to 87 mm. long; perianth greenish-yellow, infundibular,

broad, 4 to 5 cm. from base of style to tips of lobes, which are a little longer than the tube; filaments inserted a little above the middle of tube and much protruded; anthers 27 mm. long; style at length 11 cm. or more; capsule sessile, cuspidate, 6 to 7 cm. long, slender; seeds 7 to 8 mm. in longest diameter; flowers filled to the brim with a whitish, slightly nauseating nectar.—Trans. St. Louis Acad. iii. 314 and 579, Collected Writings, 311, 316. (Plates 44 and 47 are taken from Engelmann's illustration of the plant which bloomed at the Garden).— Terr. Monogr. 49; Baker, Amaryllideae, 172.— On mesas near coast in Southwestern California, as far north as Point Loma and extending southwards in Lower California. Abundant in vicinity of Western Initial Boundary Monument.— Plates 44 to 47.

Specimens examined:— From Dr. Parry; Dr. Palmer, 1875, San Diego; G. R. Hitchcock, Nov., 1875; Missouri Botanical Garden, flowers, Feb., 1877; C. R. Orcutt, Lower California, April, 1886; G. W. Drown, San Diego, July, 1895; T. S. Brandegee, Lower California, April, 1892.

= =Leaves relatively narrow, often long; acaulescent. New Mexico and Arizona.

A. Palmeri Engelm.— Leaves numerous, ascending and spreading, deep green, usually concave on upper side, more or less glaucous, sometimes crenate, 20 to 150 cm. long, 5 to 12 cm. wide, oblanceolate, tapering; end-spine slender, brown, channeled, 20 to 35 mm. long; horny margin more or less decurrent; prickles rather close set, variable in size, large ones often alternating with smaller, flexuous or recurved; scape 25 to 36 dm. or even 65 dm. high, and may be as much as 15 cm. in diameter at base, clothed with short, broad bracts; panicle long, open; flowers greenish or yellowish-white, sometimes yellow, 40 to 55 mm. long; segments 12 to 15 mm. long, shorter than the tube, the exterior ones hooded and thickened at the apex, interior ones broader; filaments long, inserted above or below the middle

of tube, purplish; anthers 12 to 15 mm. long; capsules slender, 30 to 50 cm. long, 15 to 17 mm. wide; seeds very small for the group, 4 to 6 mm. in largest diameter. Odor very offensive.— Trans. St. Louis Acad. iii. 319, Collected Writings, 313; Terr. Monogr. 42; Baker, Amaryllideae, 178.— Southeastern Arizona and Southwestern New Mexico, ascending to 6,300 feet.—Plates 48 to 52.

Specimens examined:— From Dr. Palmer, Camp Bowie, New Mexico, 1869, and Nov., 1870, locality not given; Dr. Parry, capsule and seeds, no date; Camp near Sun Flower Valley, Dr. Gerard, No. 2, 1873; Santa Rita Mts. Dr. Engelmann, Sept., 1880; Benson, Arizona, Dr. G. R. Vasey, 1881; Santa Catalina Mts., Mr. C. G. Pringle, June, 1881, flowers yellow, and June, 1882; Mr. C. T. Brandegee, Santa Rita Mts., Nov., 1891; Dr. T. E. Wilcox, Fort Huachuca, 1893; Prof. J. W. Toumey, Santa Catalina Mts., July and December, 1894, and June 20, 1895.

Blooms early in July and matures fruit in September (Toumey). It propagates itself by offsets and sometimes also by suckers. A. Palmeri varies greatly in size, and proportional length, breadth, and thickness of leaves. Whether these differences remain constant and are correlated with others entitling them to varietal distinction I have not been able to determine. Quite young plants in the Huachuca Mountains are said to be difficult to distinguish from those of A. applanata Huachucensis, and many very short-leaved plants grow there, but the mature plants of A. Palmeri are usually recognized at a glance. The inflorescence is looser and more spreading, the flowers have shorter, broader segments, the filaments are inserted deep in the tube, the capsules are longer and more slender, the seeds are much smaller, and the mature leaves much narrower and longer. I found a plant of this species a few miles from Fort Bayard, whose leaves had a brown margin extending to the base. Professor Toumey reports that plants of A. Palmeri often have a purplish cast which

extends even to the flowers. Dr. Wilcox states that after making many and careful inquiries he is convinced that A. Palmeri is the only species used in Arizona for food or for making the liquor "Mescal."

= = = Leaves very rough.

A. ASPERRIMA Jacobi. — Acaulescent; leaves few, with few fibers, broadly spreading, very concave on upper side, rounded on lower, very rough on both sides, dull green, glaucous, 45 to 120 cm. long, thick at base, broadest for some distance in the middle, and tapering very narrowly to the compressed apex; end-spine brown, 30 to 55 mm. long, slender, terete, very pungent, decurrent as a narrow border for a considerable distance; margin somewhat repand; prickles commencing 10 to 15 cm. below apex, large, deltoid-cuspidate, 7 to 10 mm. long, spreading or reflexed, rather remote; flowers 75 mm. long; ovary 30 mm.; segments 20 mm.; filaments attached a little above the middle of tube, 70 mm. long; anthers very large, 25 to 30 mm. long: — Hamb. Gartenz. xx. (1864) 561, Monogr. 61; Baker, Amaryllideae, 173.— Plate 53.

This plant is reported as occurring spontaneously in Texas at a point about twenty miles northeast of San Antonio, and at Eagle Pass. From the former place Mr. Gurney received a plant a number of years ago, and Dr. Ten Eyck has sent a specimen leaf from the latter. Dr. Ten Eyck was kind enough to search for fruiting capsules but without success. A specimen in the Garden Herbarium sent by Mr. C. G. Pringle from "mesas near Jimulco, State of Coahuila, Mexico, April 9, 1886," has prickles more numerous than those upon the Texas specimens. The plant should be looked for in Texas at other points between San Antonio and the Rio Grande.

++ Leaf without horny margin; edge repand; teeth prominent.— AMERICANAE (Baker). (Look for A. Palmeri under Submarginatae.)

A. AMERICANA L.— Leaves oblanceolate to spatulate, 10 to 20 dm. long, 15 to 22 cm. wide, glaucous; end spine 35

to 50 mm. long, brown; marginal prickles brown, deltoid-cuspidate, unequal; scape 8 to 12 m. high, with 20 to 40 branches; flowers 75 to 90 mm. long; segments 25 to 30 mm. long, yellowish; filaments inserted above middle of tube, twice as long as segments; capsule oblong, 5 cm. long.—Sp. Pl. (1753) 323; Jacobi, Monogr. 5; Terr. Monogr. 45; Baker, Amaryllideae, 180; Danielli in Nuov. Giorn. Bot. Ital. xvii. 49 to 138.—This handsome and useful* species is said to have become spontaneous at a few places in Southern Texas. Mr. Nealley reports it as being abundant between San Antonio and Eagle Pass, among Chapparal. Professor Rolfs states that it flourishes and blooms in Florida without protection, as far north as Eustis in Lake County, and at Braidentown on the East coast. With protection it has bloomed at Jacksonville. It appears to stand the frost better than the other Agaves found in Florida, excepting of course the A. Virginica, which is reported only from the northern part of the State. Dr. Havard recommends its cultivation† for the manufacture of fiber, pulque and mescal. This is the species commonly called Maguay and Century Plant.

The central pith (pita) of Maguay stalks is very commonly used by entomologists for lining their insect boxes. Humboldt states ‡ that next to maize and potato this plant is the most useful of all the productions which nature has supplied to the mountaineers of tropical America. He mentions its use for fiber, pulque, and mescal, and also states that the juice (*xugo de cocucuyza*) of immature plants is very acrid and is successfully employed as a caustic in the cleaning of wounds. The prickles which terminate the leaves served formerly for pins and nails to the Indians. The Mexican priests pierced their flesh with them in their acts of expiation. He says that the ancient Aztecs macerated the leaves

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* See section "Economic Uses" in preliminary portion of this paper.

† Proceedings U. S. National Museum, 1885, 519.

‡ Essai Politique sur la Nouvelle Espagne (Paris, 1811), tom. ii. 418 to 423.

and disposed them in layers like the fibers of the Egyptian papyrus and the mulberry (Broussonetia) of the South Sea Islands. This formed paper upon which their hieroglyphics were painted. Their manuscripts were folded in rhombic form and were bound in some resemblance to our quarto books by fastening wooden boards to the extremities. Humboldt states that no nation of the old continent made such an extensive use of hieroglyphics and in none do we see real books bound in the way described.

+++ Leaf without horny margin, slightly if at all repand; teeth small if present.—RIGIDAE (Baker).

++ Somewhat caulescent; leaves usually entire.

A RIGIDA SISALANA Engelm.— Leaves bright dark green, 120 to 180 cm. long, 10 to 14 cm. wide, narrowed, thickened and keeled above the base, broadest a little above or at the middle, and tapering to the apex; terminal spine terete, reddish-brown, not channeled, but slightly indented at the base, 1 to 2 cm. long, not decurrent; margin usually entire, but often with occasional sharp, unequal prickles, and sometimes with stout ones; scape 45 to 90 dm. high; panicle much branched, sometimes covering half the length of the scape, and having a width about half its length; flowers 55 to 65 mm. long; ovary rather broad; perianth campanulate, 33 to 35 mm. long; segments a little longer than the tube; filaments inserted above the middle, nearly at the line which would mark the upper third of tube, 55 to 60 mm. long; anthers 2 cm. long; capsules oblong, about 50 mm. long and half as wide. Propagation by pole plants and suckers.— Trans. St. Louis Acad. iii. 312, Collected Writings, 312; Baker, Amaryllideae, 181.— Yucatan, Southern Florida below the frost line, and the adjacent islands, including the Keys and the Bahamas.— Plates 54, 55 and 56. Dr. Havard and Dr. Coulter state that it occurs in Southern Texas.

Specimens examined: — From Merida, Yucatan, Dr. Schott, 1865; Key West, Wright, Parry, and Brummel,

1871; Miami, A. P. Garber, July, 1877; Indian Key and Biscayne Bay, A. H. Curtiss, 1872; Tampa, Dr. Geo. Vasey, 1892; Jupiter, C. R. Dodge, 1891; H. J. Webber, 1895; C. T. McCarty, 1895; Missouri Botanical Garden.

The A. rigida sisalana seems to have become fully naturalized in Florida, but it is found near spots that at some time have been under cultivation. It was first taken to Florida by Dr. Perrine from Yucatan in 1836.* It is called Yaxci, Yaxqui (pronounced Yaash-ki), by the natives in Yucatan, and is cultivated by them to some extent, but is not so productive there as their Saqui, or A. rigida elongata. In Florida the fiber is finer, longer, and stronger than that obtained from the Yucatan plants, and much is hoped for in its cultivation. It is growing spontaneously at many points along the coast between Titusville on the east and Charlotte Harbor on the west. Its largest tract is Indian Key; the largest and finest plants are found at Upper Metacombe and Boca Chica Keys. Plants were seen by Mr. Dodge on the former whose leaves were two feet above a man's head. Other large tracts are on Key West, the group of Keys including Lignum Vitae, etc., the old Perrine Grant, Biscayne Bay, Miami, Indian River, Jupiter and Juno. It has also been known in Polk County in the interior for the past forty years, where it forms impenetrable thickets "unharmed by frost, fires or any other cause." Two patches covering a quarter of an acre are said to have grown from two original plants.† The plant is also said to have been successfully introduced on the Lower Rio Grande.‡

In Florida this Agave is usually known by the name of Sisal Hemp. Its reproduction by means of "Pole Plants"

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* Senate Document No. 300, March, 1838. Report of U. S. Department of Agriculture, 1869. Fiber Investigations, C. R. Dodge, Reports 3 and 5, Depart. Agric., 1891. 1893.

† Fiber Investigations, No. 5, (1893), 17, U. S. Dept. Agric., C. R. Dodge.

‡ Proceedings of U. S. National Museum, 1885, 519, Dr. V. Havard.

is very interesting. After the blossoms begin to wither and fall away, buds develop from the stalk below and grow into small plants. After attaining a size of from three to ten inches, they fall to the ground and take root. They have very great vitality and develop into stout, strong plants. In cultivation, they are much used for planting. A single flowering stalk (pole or mast) will bear from one to two thousand pole plants; as many as twenty-five hundred have been reported. The species is said to have spread over the Keys by means of buds from the poles being driven by the currents of air and water.

This Agave matures in from six to seven years. By cutting its leaves, the period of poling is retarded, and the size and productiveness of the pole is lessened. Its average life in Florida is twelve years.

It is a question whether this variety can be divided into two forms which grow independently. Mr. Dodge* speaks of a distinctly spined form growing in some places, and the common smooth-leaved form in others. He also quotes from those who assert that both forms may be found on a single pole, and that a plant is sometimes found whose leaves are spiny-edged on one margin and entire on the other. In Yucatan the plant bears spines, and it is said that the influence of soil and climate tend to produce the smooth-leaved form from the other. The shortly spined† form is invariably shorter-leaved and stockier, and the smooth-leaved form spreads much the faster.

++ ++ Caulescent; teeth prominent.

A. DECIPIENS Baker.—Trunk 10 to 15 dm. long, clothed with the old recurved leaves; young leaves erect and ascending, mature ones spreading, becoming more and more reflexed, old ones recurved; fleshy leaf-bases clasping the considerably elongated axis and giving it a swollen and spindle-like effect; leaves usually

* Report of 1893, p. 23.

† Dodge, Report of 1891, p. 14.

10 to 13 dm. long, at Lake Worth 20 to 25 dm. long, 6 to 10 cm. wide, narrowed and thickened above the broad base, widest near the middle, acuminate at the apex, brighter green than the A. rigida sisalana; end spine brown, 10 to 15 mm. long, terete; marginal prickles small, but made conspicuous by the somewhat repand margin, very sharp, rather close-set and usually recurved; scape 50 to 60 dm. high, rather loosely branching in upper half; flowers greenish-yellow, about 75 mm. long; tube funnel-shaped; segments 16 to 17 mm. long, twice as long as tube; filaments inserted at the middle of the tube, 33 to 37 mm. long; ovary oblong; pole plants and suckers very abundant.— Kew Bulletin, July and August, 1892, 184; Fiber Investigations, Report No. 5 (1893), 33, U. S. Dept. Agric.— Plates 57, 58, 59.— Southeastern Florida, Jupiter, Biscayne Bay, Lake Worth and other points along the coast to Key West. — Specimens examined: — From Mr. C. R. Dodge, Southern Florida, 1892, 1895; Mr. C. T. McCarty, 1895; Mr. H. J. Webber, 1895; leaves and plants growing in the Garden.

This plant was so named by Mr. Baker on account of its having been frequently mistaken for the true sisal hemp, the A. rigida sisalana. This has caused considerable pecuniary loss to those who have unfortunately planted it in place of the other, as its fiber is softer and weaker. Though whiter and finer, it is very inferior to the sisalana both in quantity and quality. The false sisal may be easily distinguished by its tall trunk and bright green radiating leaves. The decipiens will grow in the shade but the sisalana will not, and while the latter is found near the coast, and near to present or past points of cultivation, the false sisal is found at a distance from both. In some places, Sand's Key, Lake Worth, etc., the growth of this form is very luxuriant; sometimes it rises to the height of four meters from the ground, and bears leaves two to two and a half meters long, and a mast over six meters high, and seven to ten centimeters in diameter. Its juice is very

acrid, and is poisonous to the human skin, causing intense irritation. It is a very showy and handsome plant.

Mr. Dodge* refers to this plant as being cultivated in the Botanical Garden at Washington, D. C., under the name of A. Mexicana. There is also a fine plant at one time labeled A. Mexicana growing in the Missouri Botanical Garden, which is figured in plate 56. This is obviously not A. Mexicana, but identical with the Florida plants. Mr. Gurney, the head gardener, says that it was sent to Dr. Engelmann by Dr. Parry from Northern Mexico. This perhaps indicates the native home of the species. A glance at the plate will show the abundance of suckers developed close to the trunk of the parent plant. The old recurved leaves are trimmed off.

++ ++ ++ Acaulescent; teeth very minute.

A. SP.— Leaves ascending and spreading, on young plants rather thin, brittle, and much recurved, on old plants very numerous, fleshy, heavy, and slightly recurved, light bluish-green, glaucous, 15 to 28 dm. long, 20 to 25 cm. wide, very thick at base, broadest at the middle, tapering to the apex, somewhat rough; end spine brown, terete, very narrowly channeled for a short distance; marginal prickles very minute and close-set, somewhat tinged with brown; scape nearly 13 m. high, branching at about one-fifth of the distance from the top; branches bracteate; flowers yellowish-green, (dried) 55 mm. long; segments narrow, 23 mm. long; filaments inserted above the middle of the tube, protruded for a considerable distance; ovary 20 mm. long, slender; pole plants and suckers numerous.— Plates 60 and 61.— Florida. Occasionally to be met with from Indian River to the Perrine Grant,— at Jupiter, Lake Worth, Cocoanut Grove, etc.

Young plants were received at the Garden last season from Mr. Kirk Munroe, Cocoanut Grove, Mr. C. T.

* Report No. 3, Fiber Investigations, Dept. Agric., 1891, 43.

McCarty, Ankona, Mr. H. J. Webber, and Mr. C. R. Dodge.

Mr. Munroe writes that a plant of his figured by Mr. Dodge * grew finally to be eight feet tall and about thirty feet in circumference before it flowered. A single leaf about five feet long, weighed eight pounds. It matured at seven years of age and "shot up a pole 40 feet high." I have based my description of the inflorescence upon his plant and a specimen sent by Mr. Webber from the sub-tropical laboratory at Eustis. No capsules were reported from either place.

To avoid further confusion in nomenclature, I refrain from giving a name to this plant until it is possible to obtain further data. Mr. Dodge states that it is allied to A. Americana, and that the fiber is similar in every respect, crinkly and elastic, and very white. He writes me that Mr. Smith of the Botanic Garden at Washington calls the plant A. pruinosa. I find, however, that A. pruinosa is described as having no pungent end-spine and is altogether a decidedly smaller plant, with different leaf proportions. Mr. Webber writes that it is cultivated at Eustis under the name of A. rigida recurvata. I am unable to trace any record of such a variety of A. rigida, and do not feel sure that the plant belongs to that species.

Reasoner Brothers, of the Royal Palm Nurseries, of Oneca, Florida, catalogue and figure a plant under the name of A. recurvata, which I supposed might be identical, though they do not state whether the plant is a Florida Agave, or give any adequate description. Upon writing to them, they replied that the name is a misnomer, and that they do not know of the plant being so catalogued elsewhere. They suggest that it may be A. striata var. recurva. This it certainly is not. Upon receiving the plants last spring, I was struck by their resemblance to specimens in the Agave House here labeled A. miradorensis, and this resemblance

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* Report No. 5 (1893), 38.

has now become even more striking in all points save in rapidity of growth; these young specimens having in a single year nearly reached the size of the older plants, which have scarcely grown at all. These older plants were raised from seed sent to the Garden several years ago. Mr. Gurney says that they are the same as plants called A. albicans by Dr. Engelmann, but that species belongs to the Littaea section. The plants in question seem to correspond better with those from Florida than to the descriptions given of either A. miradorensis or A. albicans.

A. SP.— A fragment of a leaf sent by Dr. B. D. Ten Eyck from Eagle Pass, Texas, Feb. 7, 1895, still remains unidentified.

The leaf is dark green, with a smooth shining surface, about 25 dm. long, 12 to 20 cm. wide, tapering to the apex, with a slight compression at the tip, giving an acuminate aspect, 3.5 mm. thick, soft, flexible, with few fibers; end-spine 4 cm. long, reddish-brown, slightly channeled on upper side for about half the length, and decurrent for a short distance; margin entire.

Dr. Ten Eyck states that this plant, which is probably a Mexican species, is found spontaneous on the northern side of the Rio Grande in the vicinity of Eagle Pass. I have been unable to learn anything in regard to its inflorescence. Dr. Ten Eyck thinks that its occurrence may possibly have been caused by seeds carried to the spot from cultivated plants. He looked for fruit without result.

EXPLANATION OF PLATES ILLUSTRATING AGAVES.

The line drawings have been made by Miss Grace E. Johnson under the supervision of the author, from herbarium material or from living plants. The half-tones are from photographs of plants under cultivation or in their native habitats.

Plate 30 is taken from Dr. Trelease's plate (No. 32), in the Fifth Report of the Garden. Plates 44 and 47 are

from Engelmann's Collected Writings, pages 315 and 319. Plates 54, 55 and 58 are reproduced by permission of the Secretary of Agriculture from Reports No. 3 and No. 5 on Fiber Investigations, by Mr. C. R. Dodge.

Plate 26. *A. Virginica* L.—Photograph of wild plants at Jefferson Barracks, St. Louis, taken by Mr. H. J. Webber.

Plate 27. *A. Virginica* L.—1, Leaf from living plant in Missouri Botanical Garden, × ½; 2, inflorescence from Little Stone Mountain, Ga., × ½; 3, interior of flower, × 1; 4, opened bud showing folding of filaments, × 1; 5, flower from Shannon County, Mo., showing curvature of filaments near point of insertion; 6, ripened capsules, × 1; 7, seed, × 2.

Plate 28. *A. maculata* Regel?—1, Living plant at the Garden commencing its spring growth, × ⅛; 2, margin of leaf, × 3; 3, portion of inflorescence from Corpus Christi, × ½; 4, flower of same, split open, × 1; 5, flower from Dr. Wislizenus, No. 373, × 1; 6, flower from Dr. Palmer, No. 1306, × 1; 7, stigma, × 4.

Plate 29. *A. Schottii* Engelm.—1, Inflorescence, × ½; 2, flower split open, × 1; 3, fruit, × 1; 4, capsule, × ½; 5, *A. Schottii serrulata*, plant, × ½; 6, margin of leaf base, × 3; 7, flower split open, × 1.

Plate 30. *A. parviflora* Torrey.—1, Vegetating plant, × 1; 2, leaf, × 1; 3, portion of fruiting spike, × 1; 5, seed, × 2;—all from Professor Toumey's material; Fig. 4, capsule, × 1; 6, leaf, × 1; 7, flowers, × 1; 8, seed, × 2;—all from Schott's specimens in the Engelmann herbarium.

Plate 31. *A. Lechuguilla*, Torrey.—1, From habit sketch taken by Dr. Trelease in Texas; 2, outer side of leaf of plant in the Garden, × ½; 3 and 4, cross-sections at middle and near base of leaf; 5, end-spine and decurrent margin seen from face of leaf; 6, portion of inflorescence, × ½; 7, flower split open, × 1; 8, fruit in position, × ½; 9, capsule, × 1; 10, seed, × 2.

Plate 32. *A. Utahensis*, Engelm.—1, Leaf from Peach Springs, Arizona, × 1; 2, portion of inflorescence from St. George, Utah, × ½; 3, flower split open, × 1; 4, capsule, × 1; 5, seed, × 2.

Plate 33. *A. deserti*, Engelmann.—Photograph taken by Parker, San Diego, kindly sent by Mr. F. Sutphens, Witch Creek, Cal.

Plate 34. *A. deserti*, Engelm.—1, Habit sketch reproduced by permission of Dr. Britton from colored drawing in Torrey Herbarium, made by Mr. G. M. Stanley, on Emory's Expedition, Nov., 1846; 2, portion of inflorescence, × ½; 3, insertion of stamens; 4, capsule, × 2.

Plate 35. *A. applanata*, Lem.—1, Outer side of leaf of large plant, × ½; 2, end-spine and margin from face of leaf, × ½; 3, outer leaf of young plant, × ½; 4, portion of fruiting branch, × ½; 5, interior of flower, × 1. All collected by author on Sierra Blanca Mts., Tex.

Plate 36. *A. applanata Parryi*.—From photograph sent by Dr. Parry to Dr. Engelmann, 1868, showing plant in San Francisco Mountains, Arizona.

Plate 37. *A. applanata Parryi.*— 1, Leaf, × ½; 2, branch of inflorescence, × 1; 3, flower with perianth split open, × 1; 4, anther, × 1; 5, capsule, × 2. All from Engelmann's type specimens of A. Parryi, collected by Dr. Rothrock, at Rocky Cañon, Arizona.

Plate 38. *A. applanata Parryi.*— From photograph taken by author near Copper Flats, New Mexico. Opuntia arborescens Engelm. is seen at the left.

Plate 39. *A. applanata Parryi.*— 1, Outer side of leaf of medium sized plant, × ½; 2, end-spine and margin from face of leaf; 3, flower, showing insertion of stamens, × 1; 4, portion of fruiting branch, × ½; 5, capsule, × 1. Leaf from plant sent to Garden from Pinos Altos Mts.; flowers and fruit from Copper Flats, New Mexico. All collected by author.

Plate 40. *A. applanata Huachucensis.*— From photograph taken by Dr. T. E. Wilcox, U. S. A., in Huachuca Mts.

Plate 41. *A. applanata Huachucensis.* — Habit sketch of young plant sent by Dr. T. E. Wilcox, U. S. A., from Fort Huachuca.

Plate 42. *A. applanata* Lem.—From photograph of plant blooming at the Garden, June, 1879.

Plate 43. *A. applanata* Lem.— From specimens in Engelmann Herbarium, of plant blooming in the Garden, June, 1879. 1, Leaf dried without much pressure, therefore wrinkled, × ½; 2, 3, 4, portions of bracts, × ½; 5, flower from within, × 1; 6, capsule, × 1; 7, seed, × 2; 8, portion of surface of seed, much magnified.

Plate 44. *A. Shawii* Engelm.—From Dr. Engelmann's Collected Writings, page 315.

Plate 45. *A. Shawii* Engelm.— 1, From photograph taken by Parker & Parker, San Diego, borrowed from Gray Herbarium; 2, from photograph of young plant at Missouri Botanical Garden, in 1887.

Plate 46. *A. Shawii* Engelm.—1, Leaf of plant at the Garden, × ½; 2, bract of inflorescence, from Engelmann herbarium, × ½: 3, capsule, × 1.

Plate 47. *A. Shawii* Engelm. — From plant blooming at the Garden, Feb., 1877. Plate taken from Engelm. Collected Writings, 319. 1, Diagram of flower; 2, outer view of top of flower-bud; 3, inner view of same; 4, an opening bud; 5, section of same; 6, flower fully open; 7, flower on third day; 8, flower on fifth day; 9, stigma closed, × 4; 10, stigma expanded, × 4; 11, pollen grains, × 100.

Plate 48. *A. Palmeri* Engelm. — From photograph taken by Dr. T. E. Wilcox, U. S. A., near Fort Huachuca, Arizona.

Plate 49. *A. Palmeri* Engelm.— From photograph taken by Dr. Trelease, of plant sent to the Garden by Mrs. Angus Campbell, from Mule Springs, New Mexico. — The repand form.

Plate 50. *A. Palmeri* Engelm. — 1, Sections from apex, middle and base of leaf of plant collected by author at Lone Mountain, New Mexico, × 1; 2, sections from apex, middle and base of leaf of plant sent by Mrs. Angus Campbell from Mule Springs, New Mexico, × 1.

Plate 51. *A. Palmeri* Engelm. — 1, Mature leaf showing margin extending to base, × ½; 2, leaf of young plant, × ½; 3, apex of same

from face of leaf; 4, portion of flowering branch, × ½; 5, opened flower, × 1. All collected by author near Lone Mountain, New Mexico.

Plate 52. *A. Palmeri* Engelm. — 1, Flowering branch, × ½; 2, flower, × 1; 3, insertion of stamens; 4, capsules, × 1; 5, seed, × 2.

Plate 53. *A. asperrima* Jacobi. — 1, Leaf of plant in Missouri Botanical Garden, from near San Antonio, Texas, × ⅙; 2 and 3, sections of same; 4, margin of same, × 1; 5, margin of leaf from Eagle Pass, × 1; 6, margin of leaf from Pringle's specimen, × 1; 7, flower from Pringle's specimen, × 1.

Plate 54. *A. rigida sisalana.*— From Plate I. of Report No. 3, by Mr. C. R. Dodge, on the Leaf Fibers of the United States.

Plate 55. *A. rigida sisalana.*— From Plate V. of Report No. 3. Plant in flower, and a side branch of pole, showing pole plants.

Plate 56. *A. rigida sisalana.*— 1, Leaf, × ⅙; 2, 3, and 4, sections from top, middle, and base of leaf, × 1; 5, portion of inflorescence, × ½; 6, interior of flower, × 1; 7, young pole plant, × ½.

Plate 57. *A. decipiens* Baker.— From photograph taken of plant at the Garden, in 1887.

Plate 58. *A. decipiens* Baker.— From figure of inflorescence on page 30 of Report No. 5, by Mr. C. R. Dodge, on Leaf Fibers of United States.

Plate 59. *A. decipiens* Baker.— 1, Leaf, × ⅙; 2, 3, and 4, sections from apex, middle and spreading base of leaf, × 1; 5, portion of branch of inflorescence, × ½; 6, flower, × 1.

Plate 60. *A. Sp.*— From photograph of plants sent to the Garden by Mr. C. T. McCarty, from Ankona, Florida. Taken by the author.

Plate 61. *A. Sp.*— 1, Portion of leaf, × ⅙; 2, 3, and 4, sections of apex, middle and base of leaf, × 1; 5, portion of margin, × 2.

Plate 62. *A. horrida micracantha.*— From photograph of plant at the Garden, taken by the author, January, 1895.

Plate 63. 1, *A. Virginica tigrina* Engelm., young plant beginning its annual growth, sent to Garden by Dr. Mellichamp, × ½; 3, seedling of *A. applanata Huachucensis* with testa still at apex of cotyledon, × 1; 2, same, further advanced, × 1; 4, margin of first leaf, × 5; 5, 6, 7, flowers of *A. horrida micracantha;* 8, 9, 10, flowers of *A. brunnea* Watson. All from plants at the Garden.

AGAVE VIRGINICA.

AGAVE VIRGINICA.

AGAVE MACULATA.

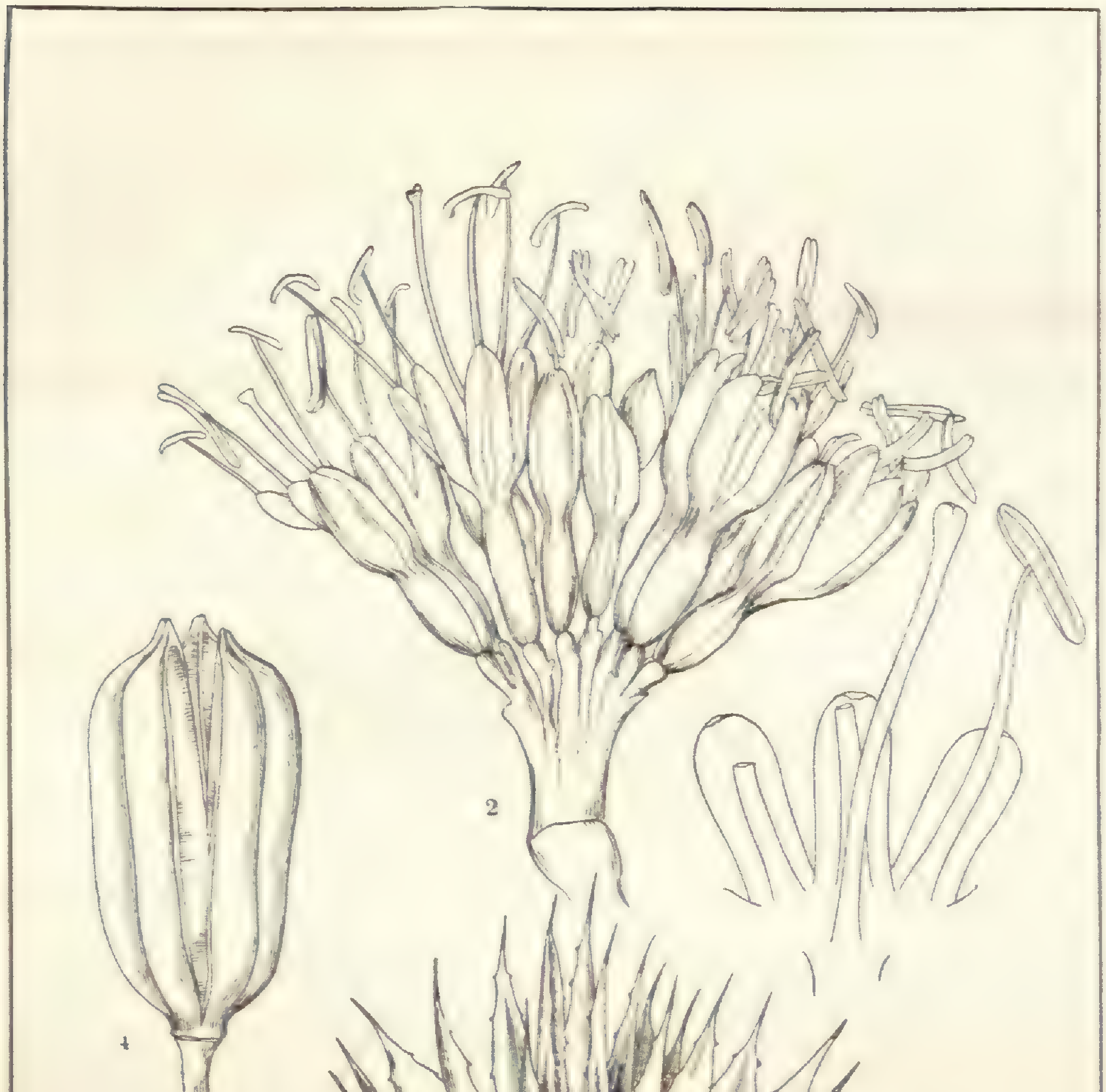
AGAVE SCHOTTII.

AGAVE PARVIFLORA.

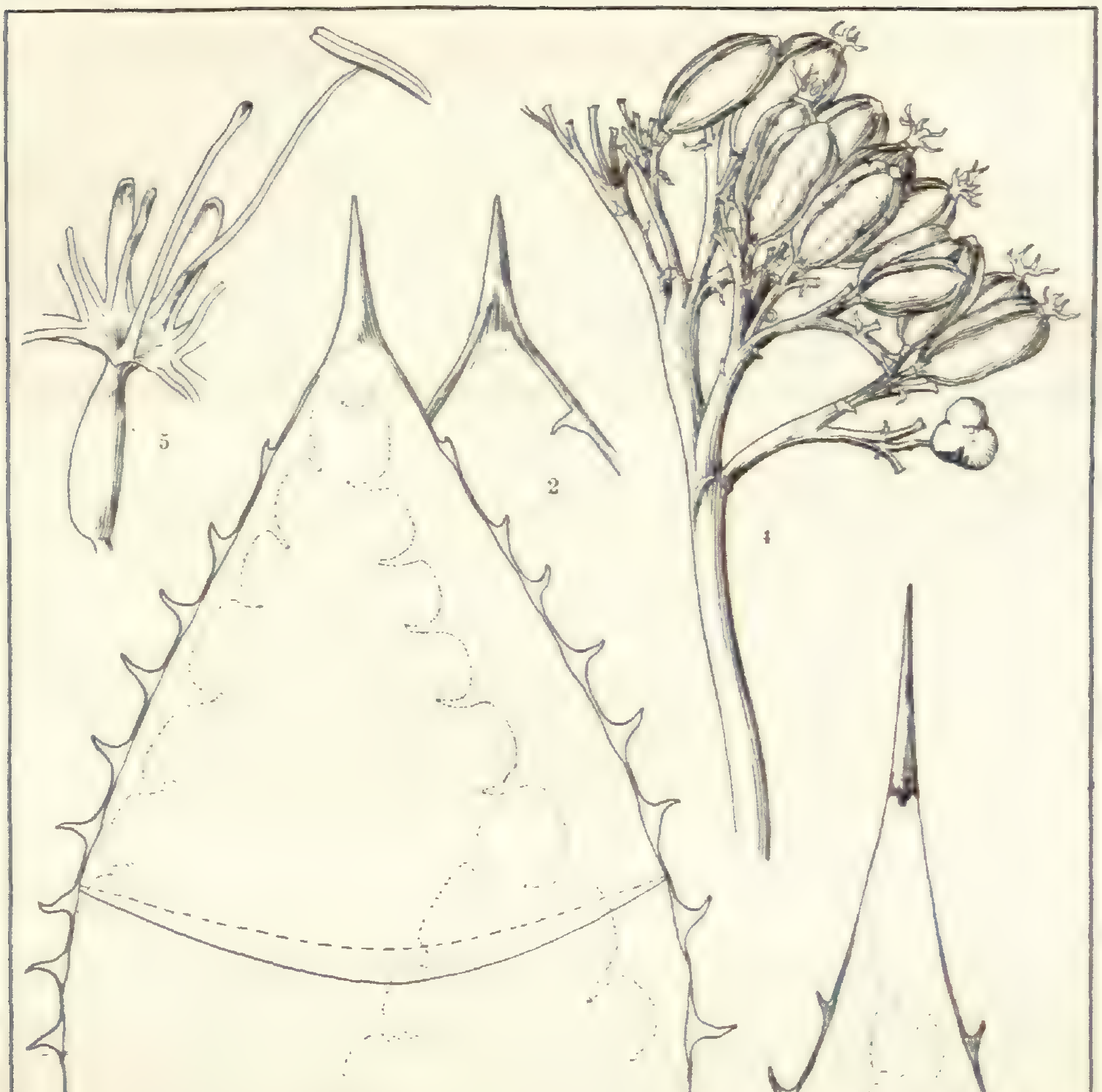
AGAVE LECHUGUILLA.

AGAVE UTAHENSIS.

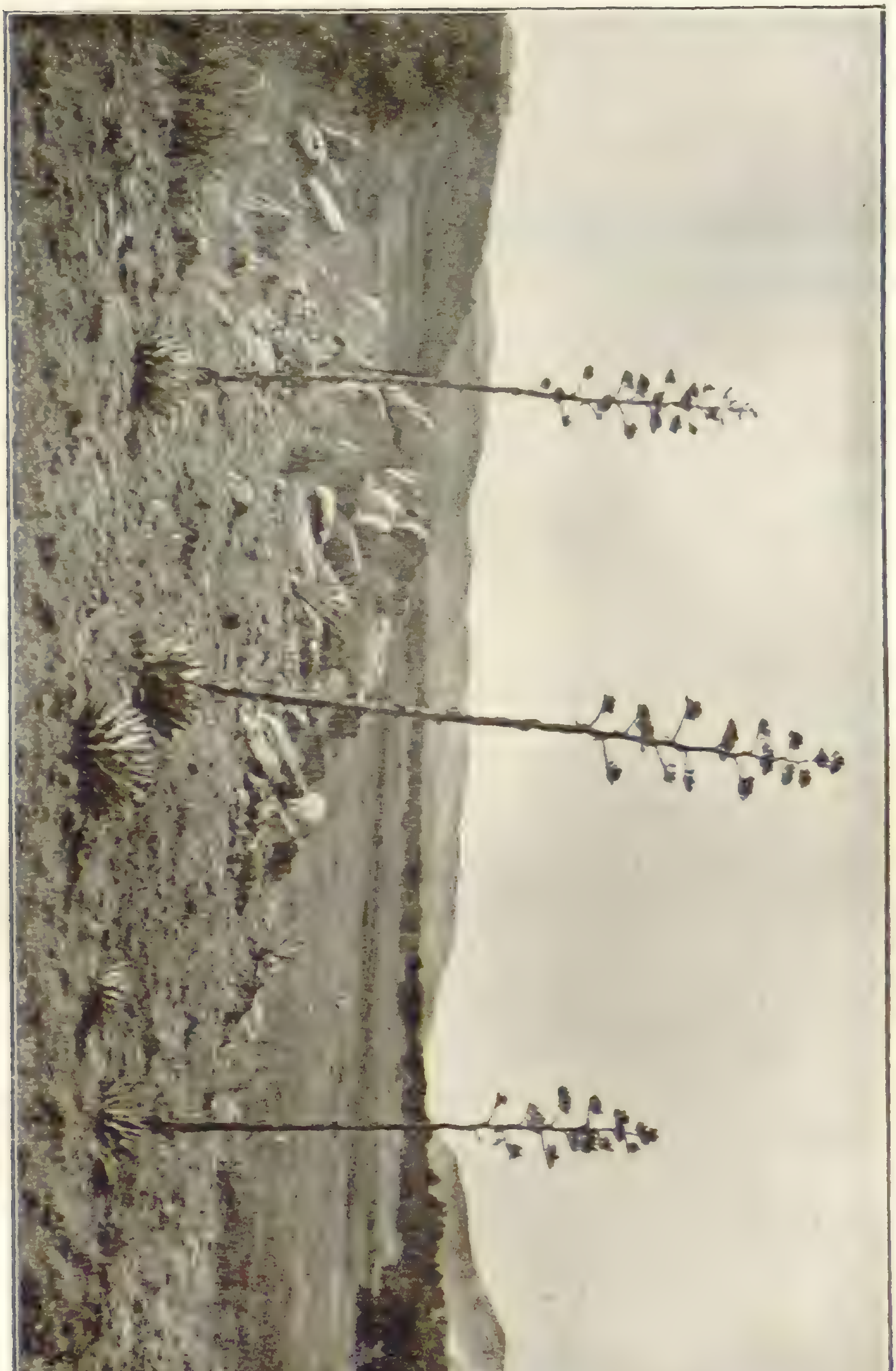
AGAVE DESERTI.



AGAVE DESERTI.



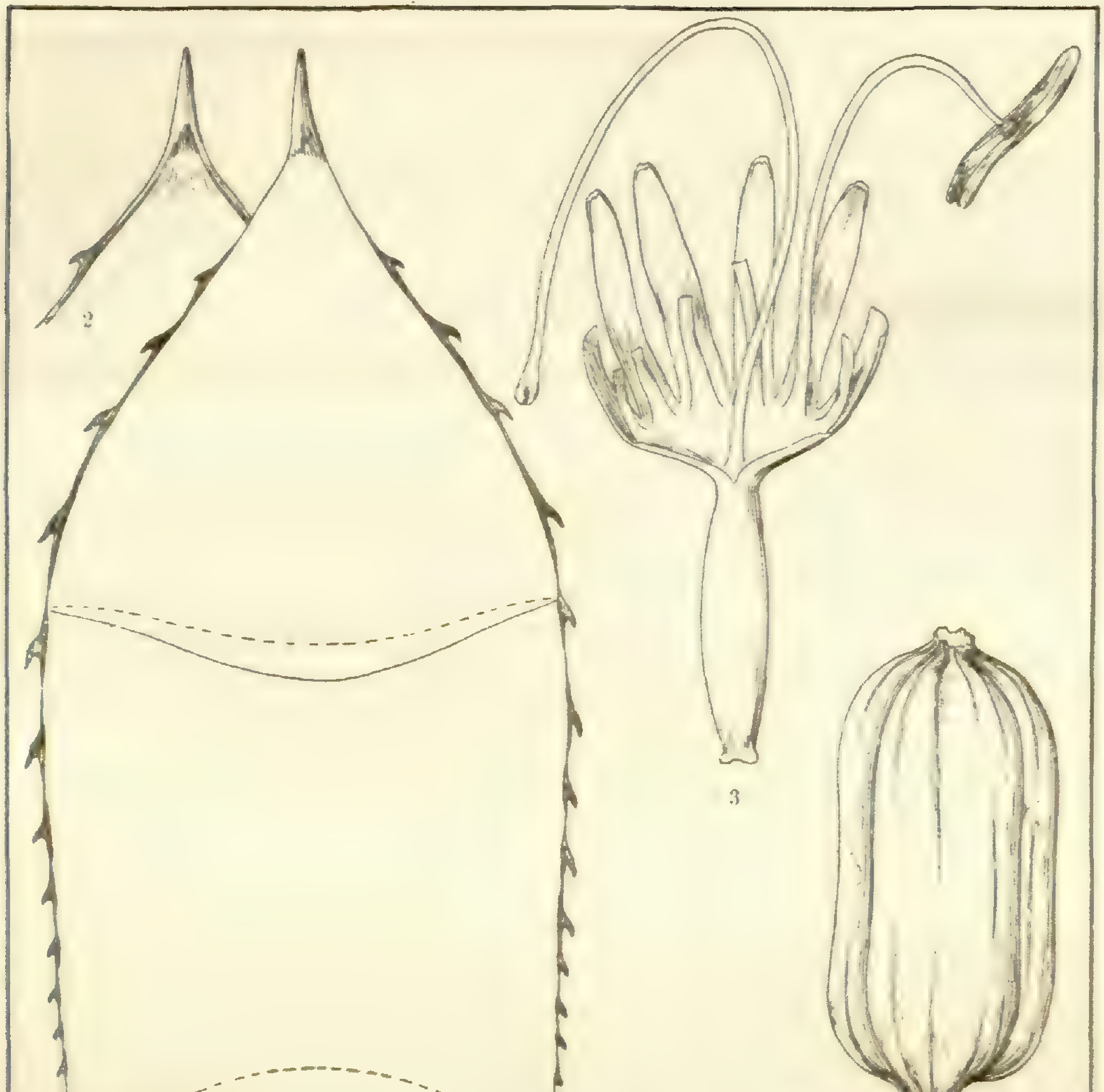
AGAVE APPLANATA.



AGAVE APPLANATA, VAR. PARRYI.

AGAVE APPLANATA, VAR. PARRYI.

AGAVE APPLANATA, VAR. PARRYI.

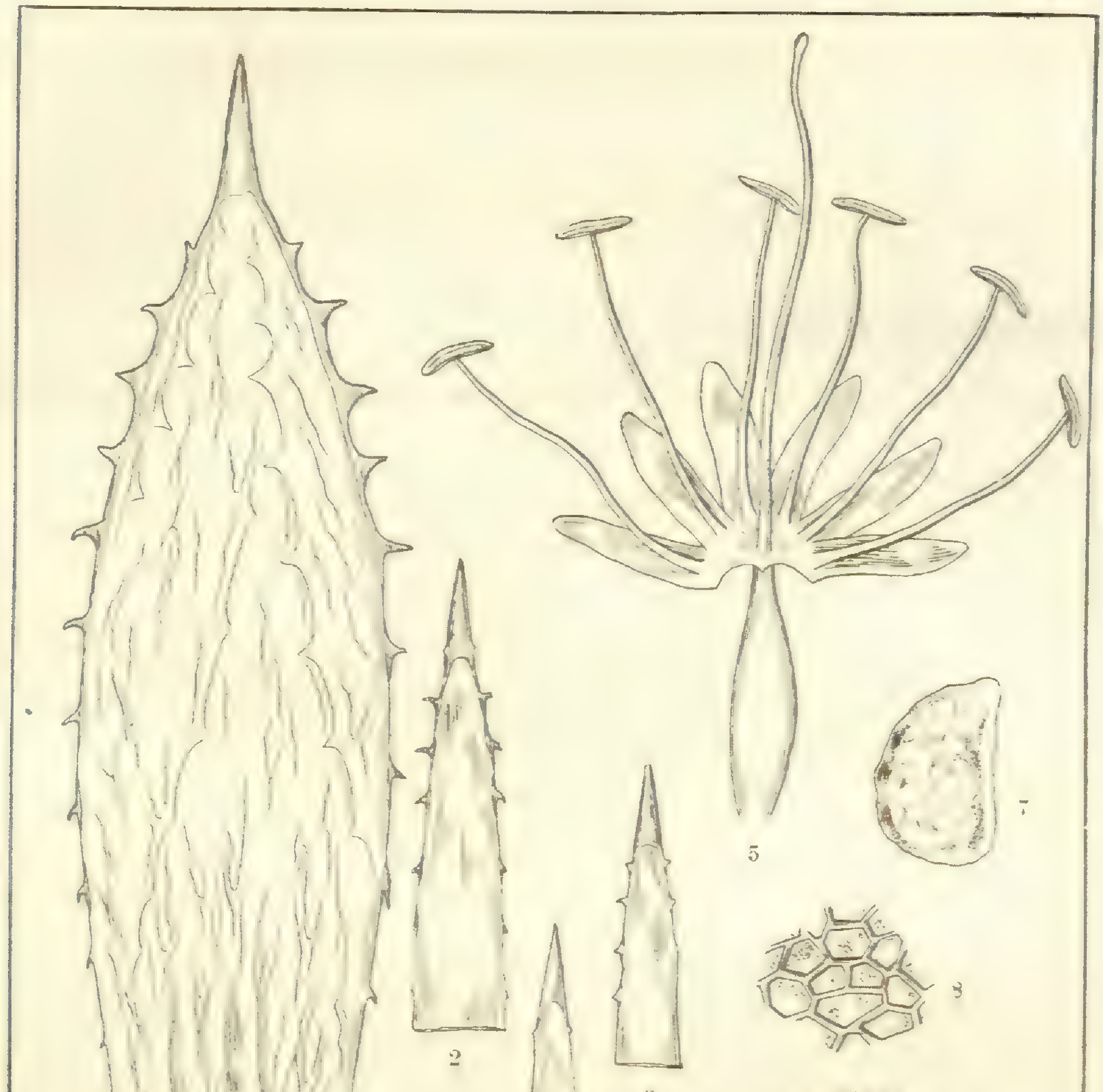


AGAVE APPLANATA, VAR. PARRYI.

AGAVE APPLANATA, VAR. HUACHUCENSIS.

AGAVE APPLANATA, VAR. HUACHUCENSIS.

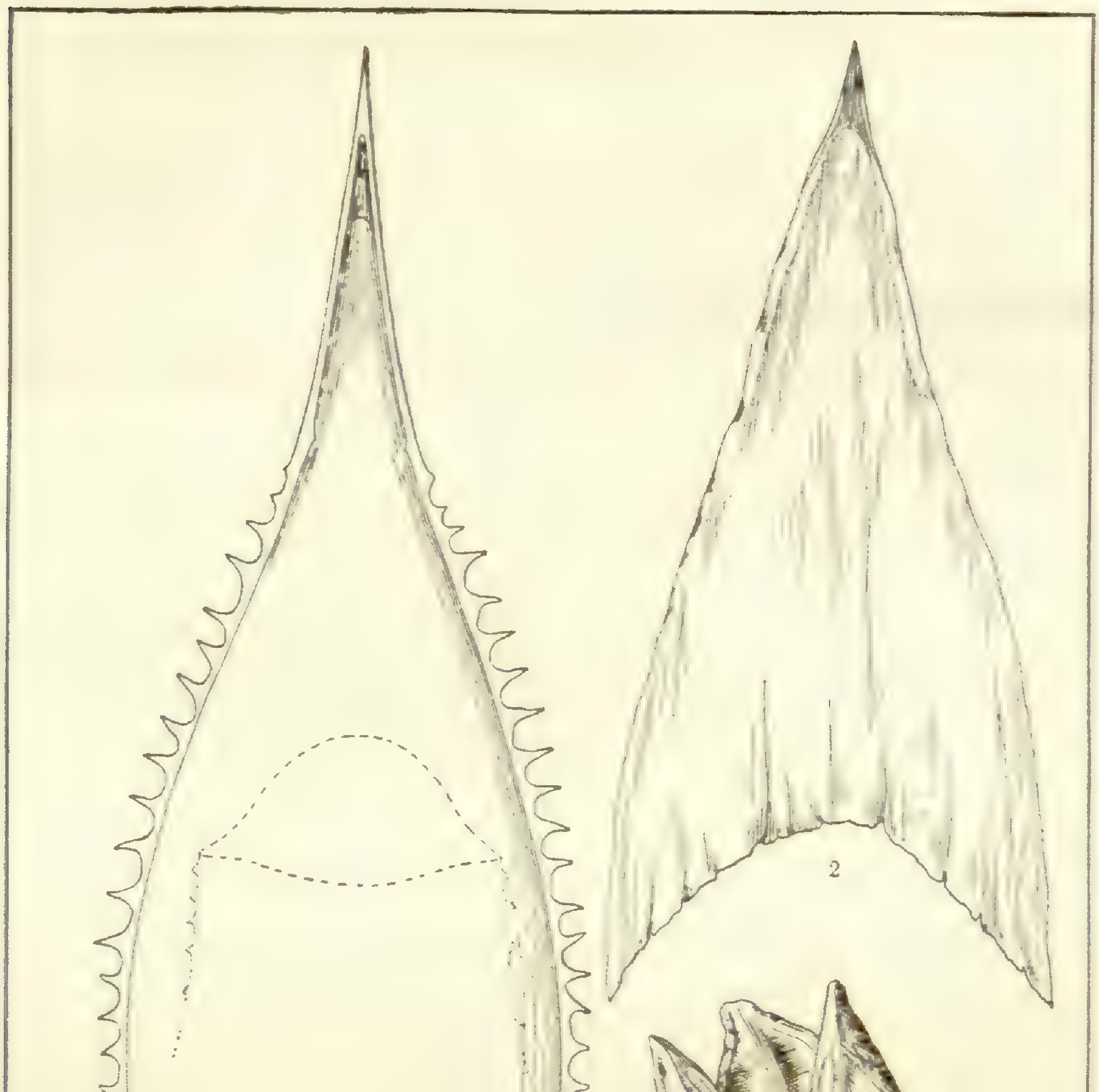
AGAVE APPLANATA.



AGAVE APPLANATA.

AGAVE SHAWII.

AGAVE SHAWII.



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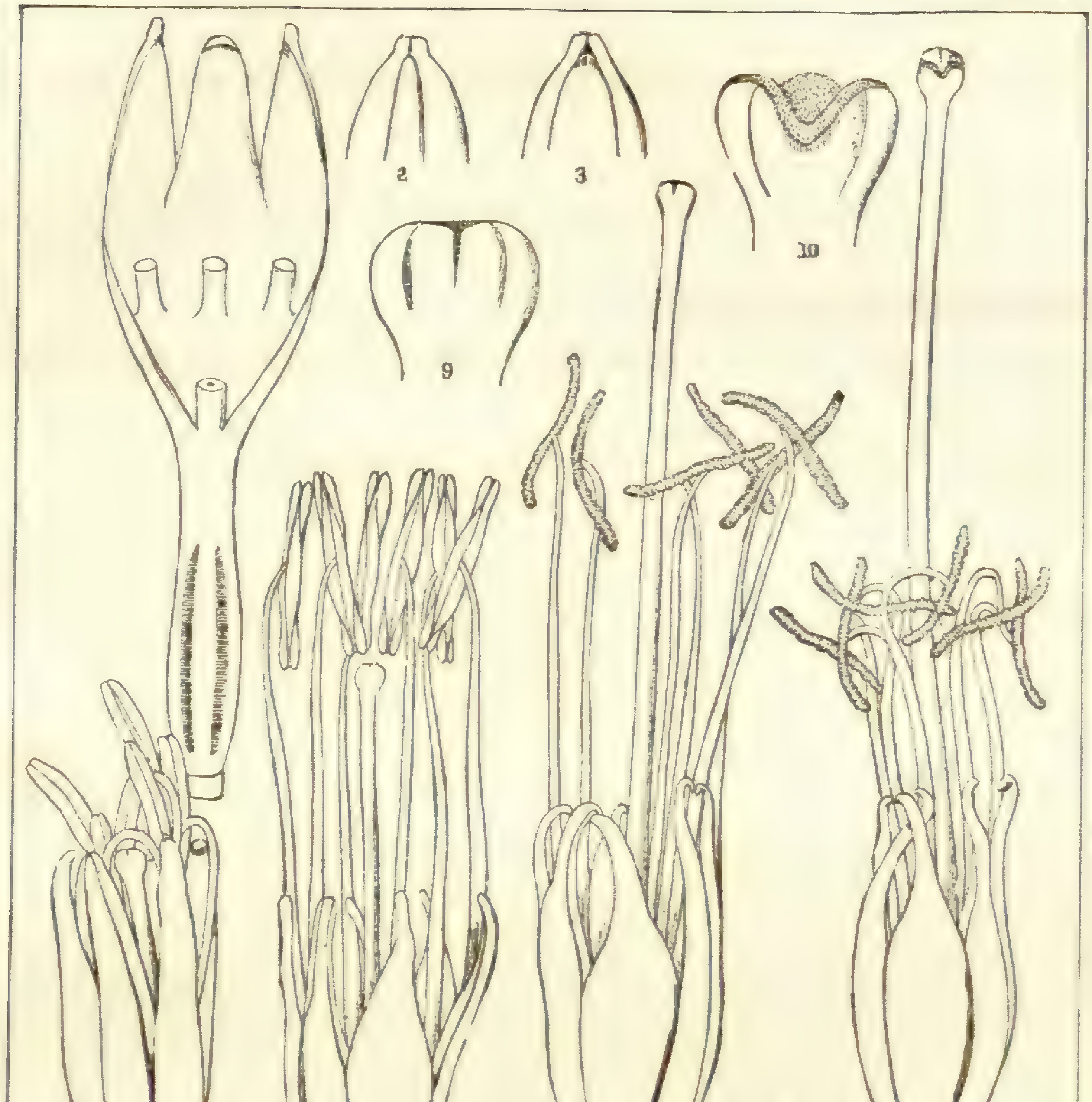
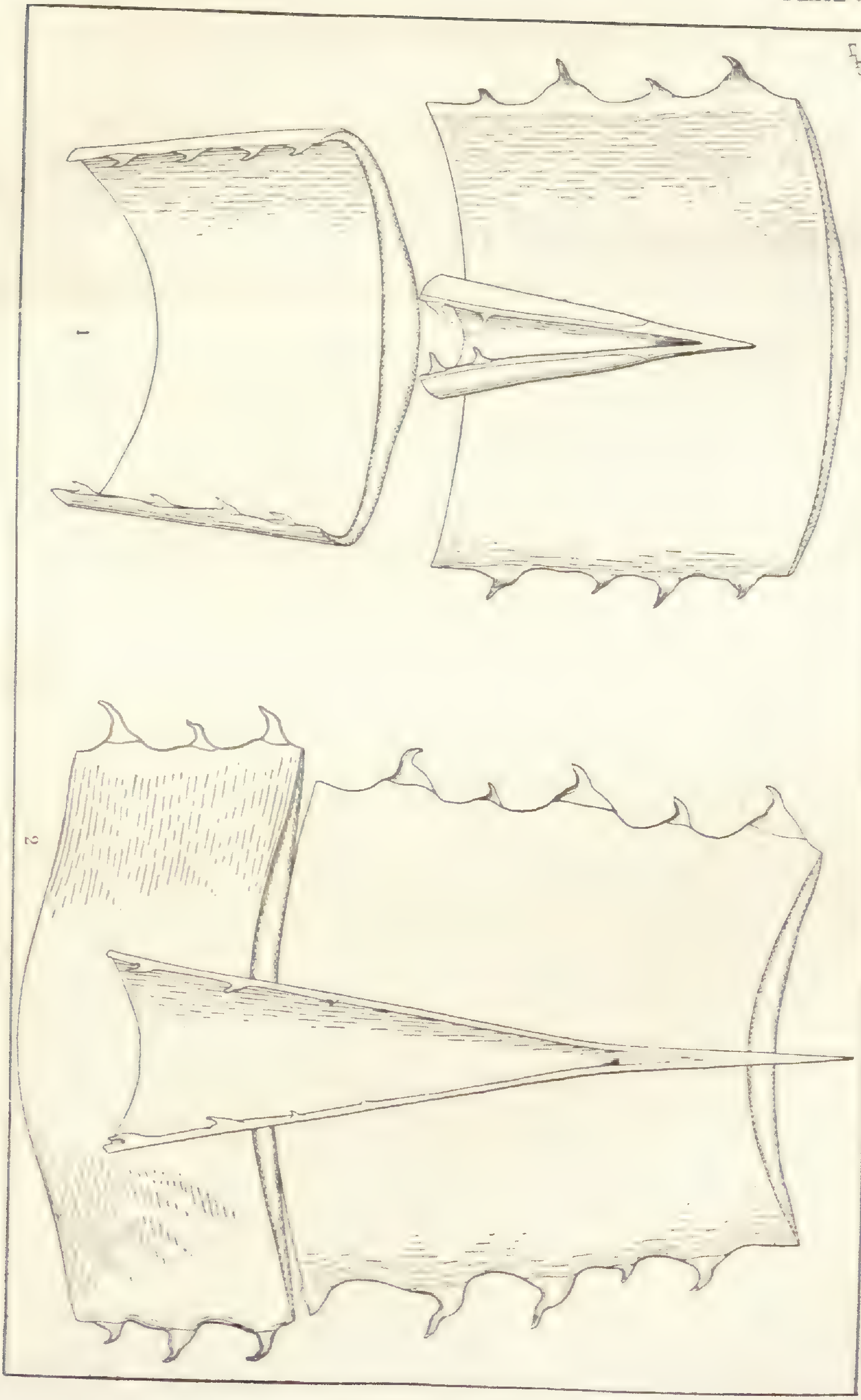


AGAVE SHAWII.

AGAVE PALMERI.

AGAVE PALMERI.



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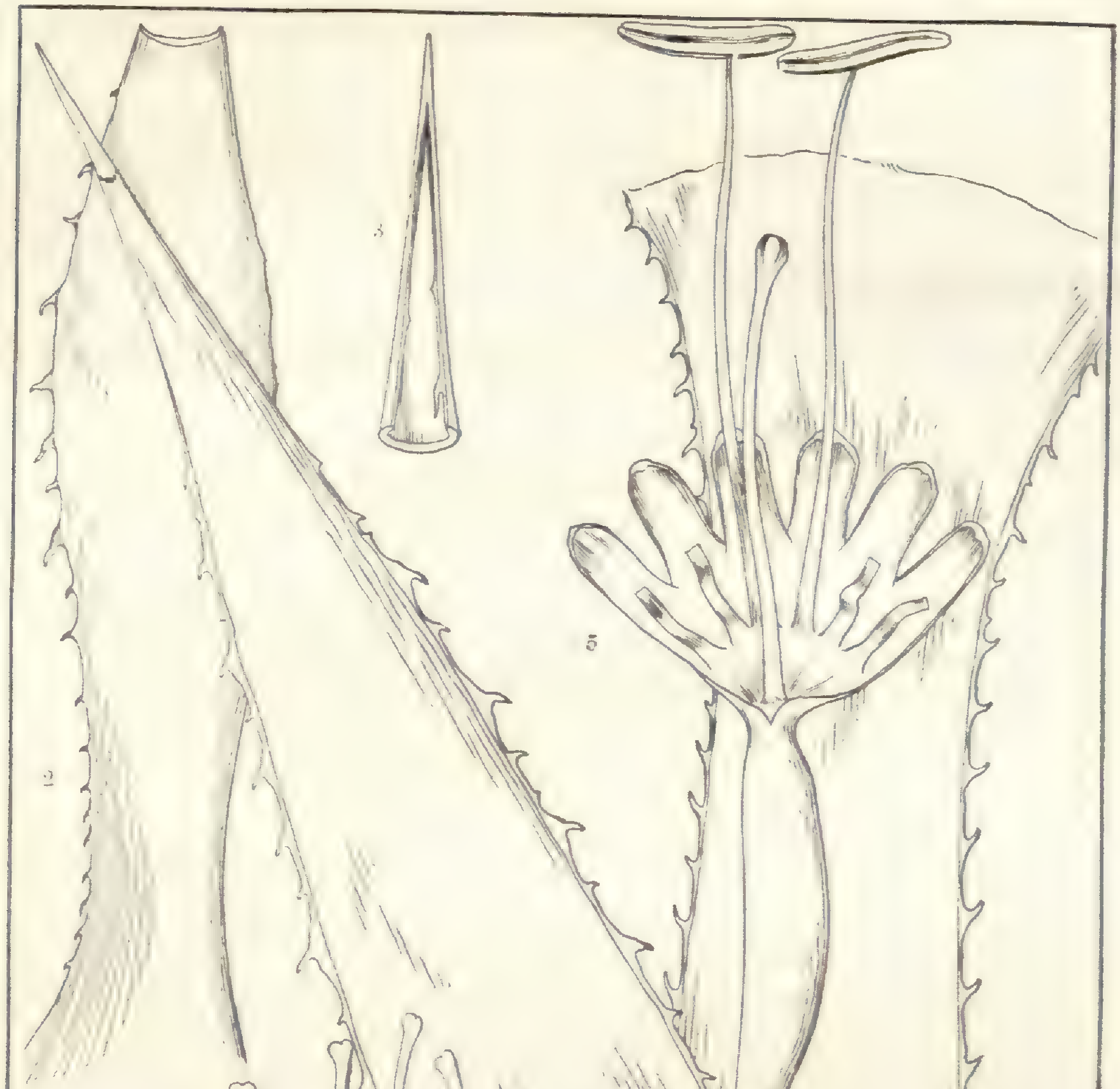

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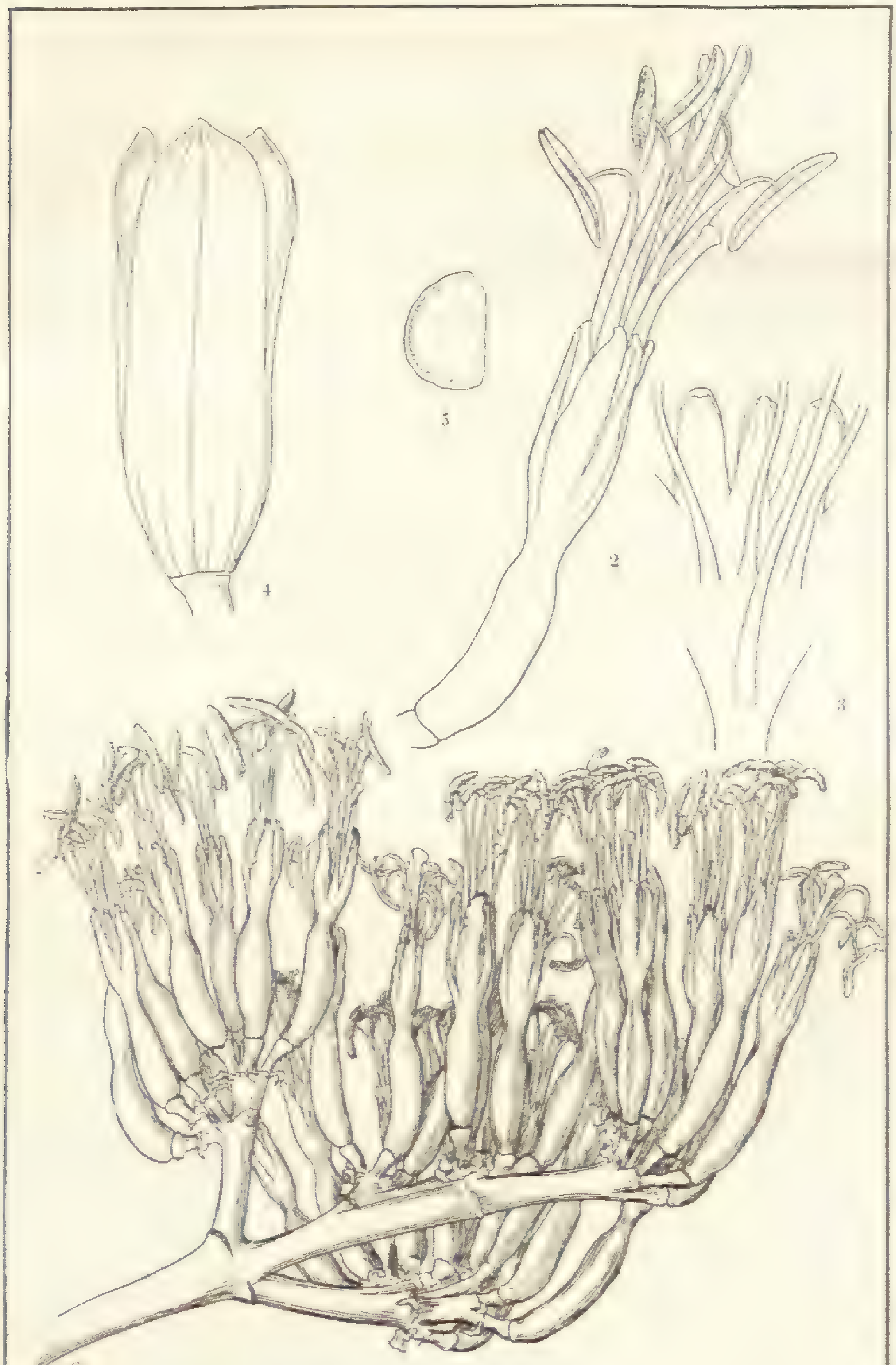
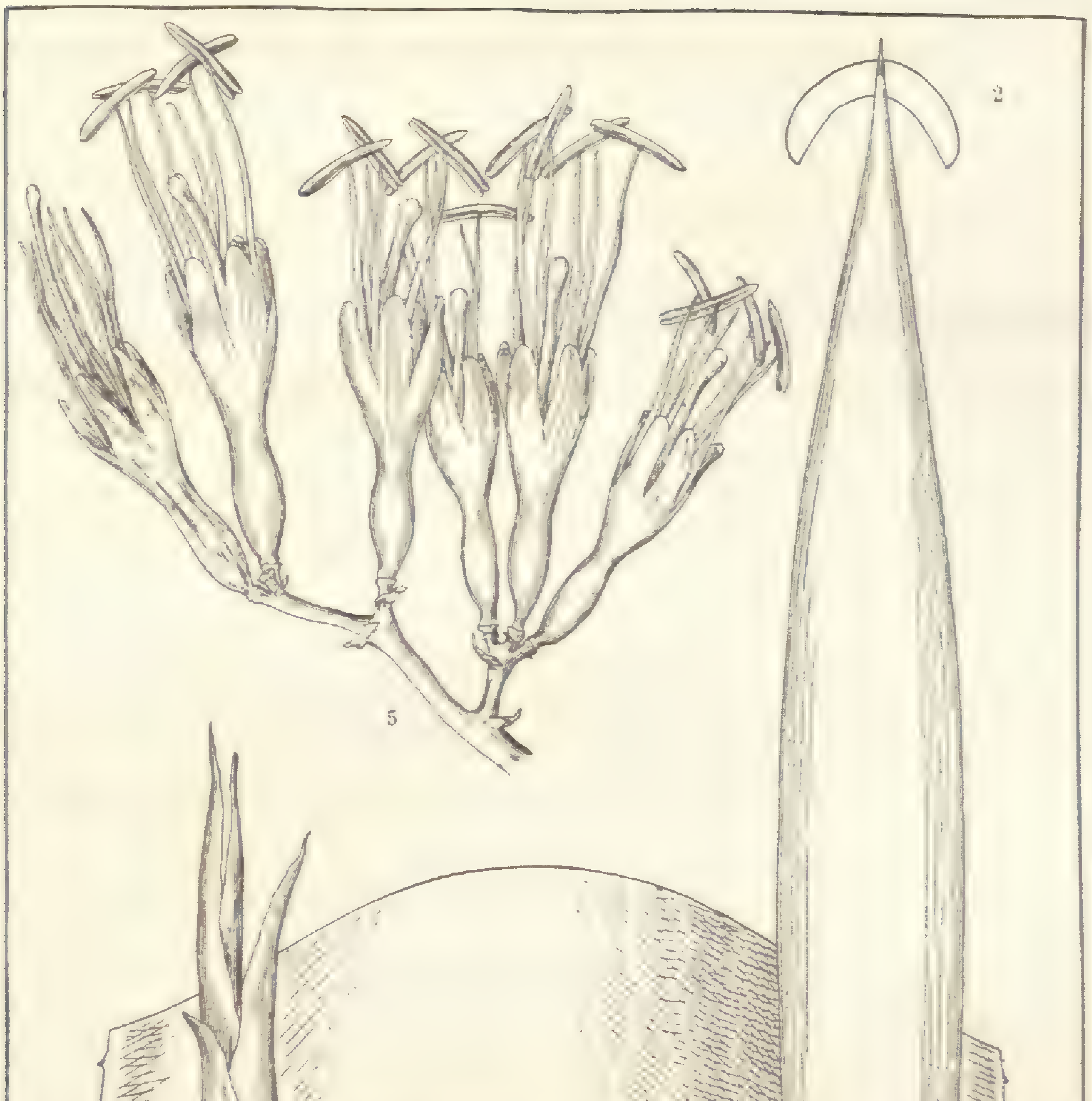


AGAVE PALMERI.

AGAVE ASPERRIMA.

AGAVE RIGIDA, VAR. SISALANA.

AGAVE RIGIDA, VAR SISALANA.

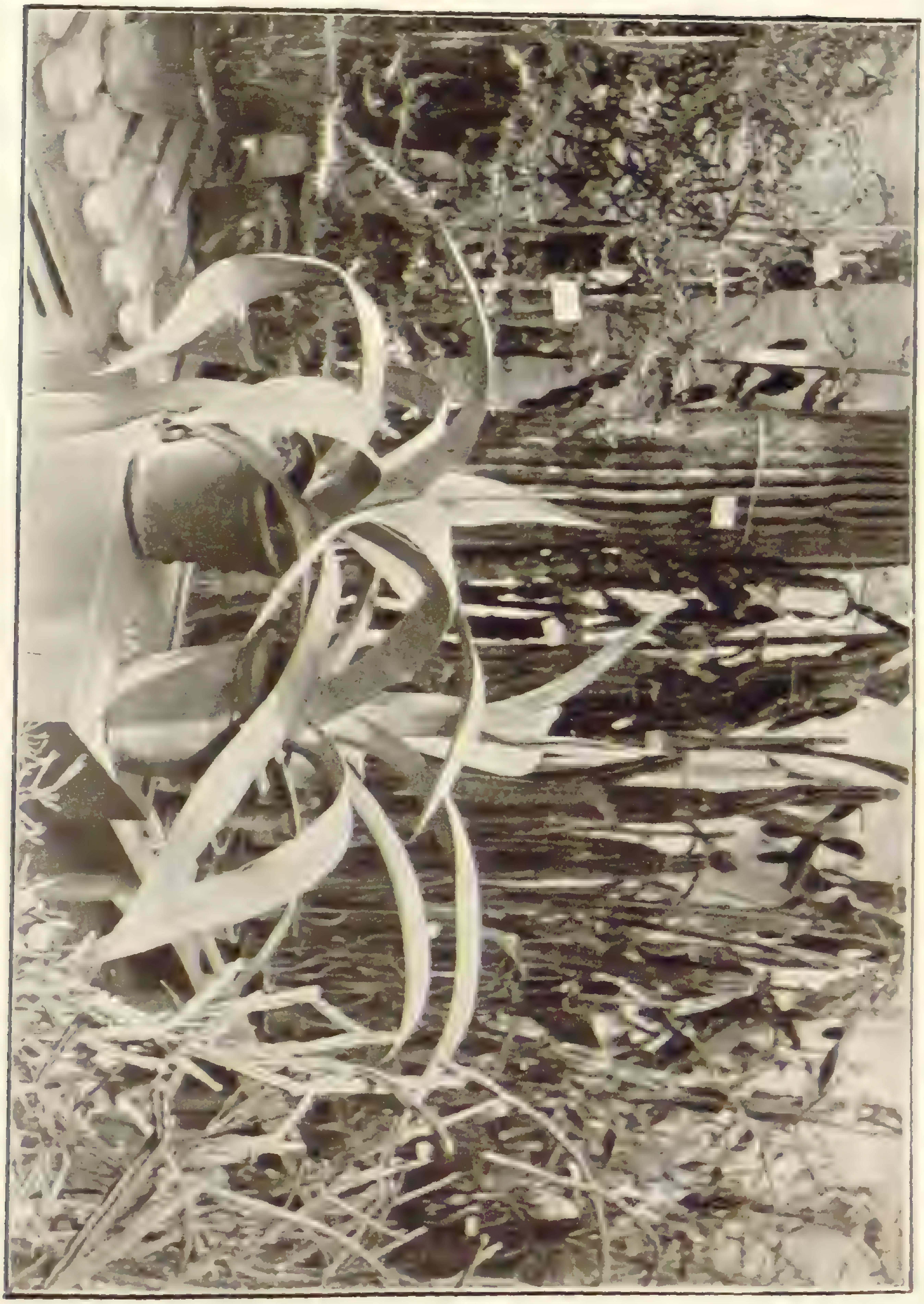


AGAVE RIGIDA, VAR. SISALANA.

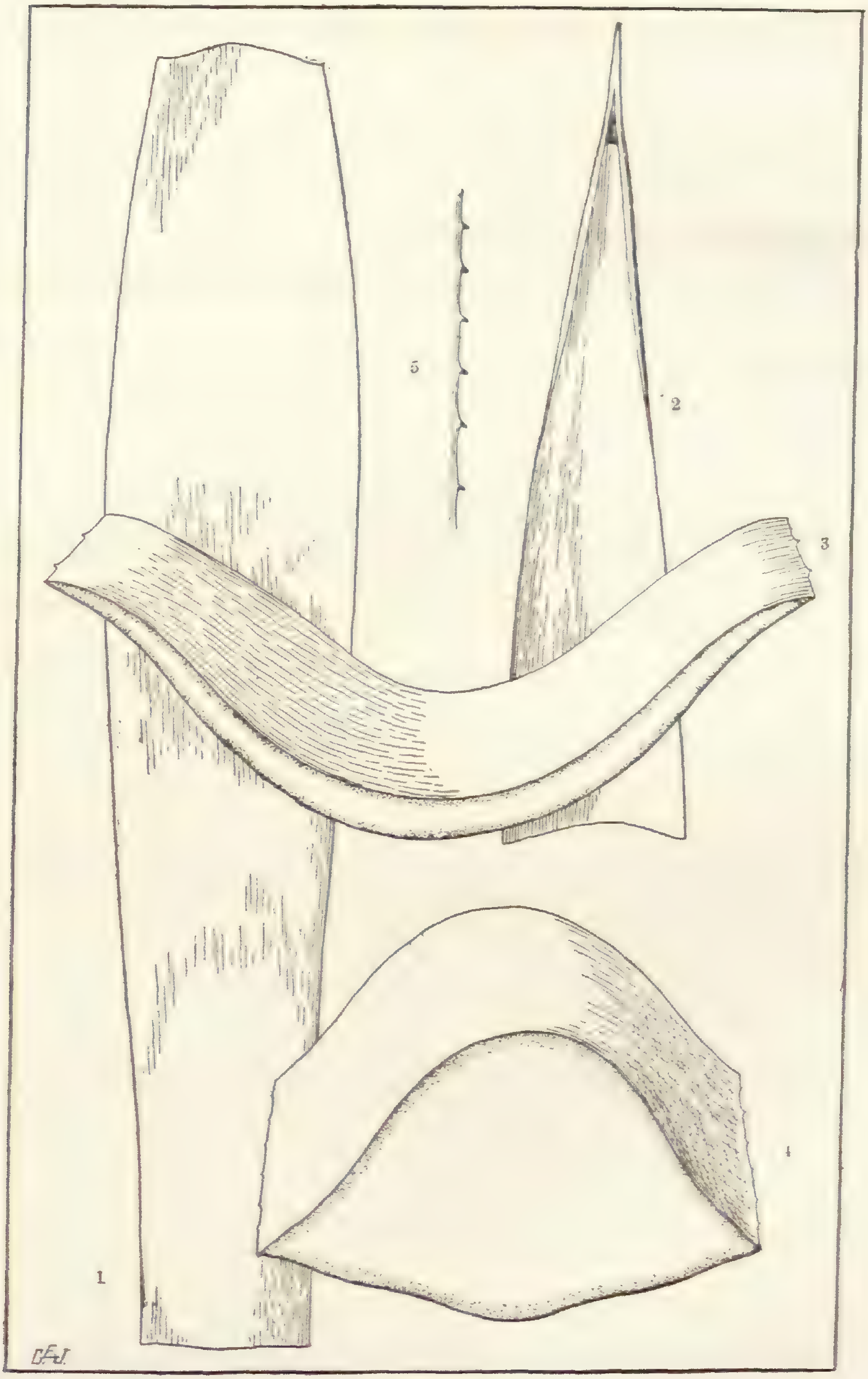
AGAVE DECIPIENS.

AGAVE DECIPIENS.

AGAVE DECIPIENS.



AGAVE SP.



AGAVE SP.

AGAVE HORRIDA, VAR. MICRACANTHA.

DETAILS OF AGAVE.

THE LIGULATE WOLFFIAS OF THE UNITED STATES.

BY CHARLES HENRY THOMPSON.

Of the Lemnaceae, represented in our flora by *Lemna*, *Spirodela*, and *Wolffia*, the Wolffias present two very marked forms designated by Hegelmaier as subgenera — *Euwolffia* and *Wolffiella*.* In our species these are characterized by small granular symmetrical fronds for the first, and comparatively large, thin, strap-like unsymmetrical fronds for the latter. *Euwolffia* is represented by two species, both of which are known to be fertile. *Wolffiella*, however, has never been known to produce flowers. Though there is no doubt that it belongs to this order, yet there is a question whether it is properly a *Wolffia*. My observations lead me to consider *Wolffiella* a good genus, as has been suggested,† with structural characters intermediate between the Wolffias proper and the Lemnas, but this distinction could hardly be recognized as conclusively generic without the support of generic differences in their flowers, which latter it is hoped will yet be discovered as their habitats are more thoroughly explored. This subgenus has heretofore been reported as having but one representative in the United States, and that a variety of a Mexican species, growing in the subtropical region of Florida.

Since this variety and another Mexican species have both only recently come under my notice — both from new localities with us — it seems fitting that a careful report be made on them from the facts which I have been enabled

* Hegelmaier: Die Lemnaceen, pp. 122, 131.

† J. D. Smith: Bull. Torr. Bot. Club, VII. 65.

to glean from a study of them, and it is with a view to add these to the general knowledge of Lemnaceae that I append the following notes.

WOLFFIA GLADIATA FLORIDANA, J. D. Smith.

During the past summer the Garden received from the collector, Mr. B. F. Bush, a small package of aquatic plants, mostly of the order Lemnaceae, collected in the swampy region of southeastern Missouri. These plants reached the Garden in good healthy condition and were immediately placed in a tank where they continued to thrive,—affording no little interest to many visitors.

Later it was thought advisable to separate the species into different vessels, and in doing this my attention was attracted to a number of little clusters of minute ribbon-like green bodies floating about free just beneath the surface of the water, which at first glance might easily have been mistaken for algae, but, when examined under the microscope, revealed a much higher type of organized tissue. As no fruiting bodies could be detected, some difficulty was experienced in determining in just what part of the vegetable kingdom these little organisms belonged, but at length they were identified with *Wolffia gladiata Floridana*, J. D. S.,* of the order Lemnaceae.

The typical *Wolffia gladiata*, Hegelm.† is a native of Mexico, at present reported only from the City of Mexico, where it grows abundantly in pools and ditches with kindred aquatics.

Our variety *Floridana* differs from the specific form in proportionally longer and narrower fronds, which are curved more to saber-form. Hegelmaier, the author of the species, in a letter to Capt. John Donnell Smith says, in comparing them: "Had both forms come to my knowledge at the

* Bull. Torr. Bot. Club, VII. 64 (1880).

† Hegelmaier: Die Lemnaceen, p. 133 (1868).

same time I should probably have taken the Florida plant for the type of the species inasmuch as it is constant with itself wherever you have found it; and the Mexican plant would have been treated as a var. *abbreviata*.* "

The habit of growth seems to vary according to the nature of its surroundings. In still water it collects in dense masses as intricately interwoven as the fibers of felt, while in flowing water it is more likely to be scattered — united only in small clusters which might aptly be termed families, since from the youngest up to the oldest plant each individual is attached by its stipe to the parent. These families take on a peculiar form. Each frond has a pronounced double curve — the curve edgewise of a saber and again curved sidewise as a part of a band. The young, growing from the pouch of the parent, continues in the direction of the band-like curvature of its parent so that at maturity the two form an almost regular semicircle. These each send out other young fronds which retain the curvature of their parents but are growing edge to edge with them. This multiplication is continued until an almost complete hemisphere is produced † (pl. 64, f. 9). Directly at the upper pole this hemisphere is exposed to the air at the surface of the water, and at this point also, it will be readily seen, the base of each frond is situated. This grouped formation (families) seems to be adapted to catch any slight current arising from a disturbance of the water, for if the water is agitated these inverted basket-like bodies take on a rolling, rocking motion which sinks and carries them to a considerable distance where again they come to the surface. This seems to be their mode of travel or dissemination — a sort of subaquatic tumble weed. From the curved form of the tips of the fronds it is easily seen how two or more

* Bull. Torr. Bot. Club, VII. 65 (1880).

† Looking from above, the curvature seems to be uniformly downward and to the right, though I would hesitate to make such a statement definite without further observations.

such families coming in contact would readily interlock and thus form the beginning of a mat of the plant at the surface. This mat would be intensified as the young fronds push their curved tips downward through the mass and lock the families in closer embrace. This will account for the dense masses found in many places.*

The individual plant itself is an elongated strap-like frond, about fifteen times as long as the broadest part and but a few cells in thickness, tapering from the oblique base with its broad pouch-cleft to a narrow rounded apex which is only about $\frac{1}{4}$ to $\frac{1}{3}$ as broad. The margin is entire. As stated in the introduction, the flowers and fruit of this plant are not known, but it reproduces quite freely by a form of branching or budding. At the basal end of each frond the two epidermal layers are split apart to form a deep elongated triangular pouch which extends about $\frac{1}{7}$ to $\frac{1}{5}$ the length of the frond (pl. 64, f. 7). At the bottom of this pocket, in the acute angle, the budding takes place which results in new individuals being cast off to take up a life's work in themselves. The young frond grows out from the pouch-opening in the same general direction as its parent, until of about the same length, when it takes a position at about right angles to its parent, by which time it also is sending out a young frond. In fact a frond is scarcely more than half matured before it begins to form buds in its pouch, while at the same time its parent is sending out other individuals — sister fronds — alongside it. Each frond is attached to its parent by an elongated stipe which is long persistent, thus holding individuals together for many generations, forming the families above referred to (pl. 64, f. 6).

In structure the frond consists of the two epidermal layers separated in the greater part of its length by large air chambers and united only at the margins and a small portion of its apex. They are connected in the cavernous

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* John Donnell Smith: Bull. Torr. Bot. Club, VII. 64 (1880).

part by chains of cells which form the side walls of the air chambers. These air chambers are usually hexagonal, as are also the epidermal cells — both slightly elongated in the direction of the longer axis of the frond. Uniformly scattered over both surfaces are pigment cells which differ from the surrounding epidermal cells in their smaller size and thicker walls and their yellowish-brown color and the granular appearance of their contents (pl. 64, f. 8.) The stipe, at the point where it was formerly attached to the parent plant, is composed wholly of chains of elongated prismatic cells which spread out fan-like toward the body of the frond, and in so doing present all gradations of cell-form from the prismatic at the stipe scar to the regular hexagonal form of the epidermis; however a few chains of the elongated cells extend unbroken to the base of the pouch where the budding takes place, and here connect with the stipes of the offspring, thus forming continuous chains throughout the generations. They too contain pigment cells. In this species this bundle of chains, or "costa," as Smith terms it, seems to occupy a position at the left side of the pocket — looking from above — within the line of juncture of the two walls of the pouch.*

The finding of this variety adds an interesting item to the geographical distribution of plants, since heretofore it is reported only from a few stations in Florida, yet in the light of recent discoveries of many representative Florida plants — *Leitneria Floridana*, etc, — growing in the swampy regions of southeastern Missouri, it is not surprising that the list should receive additional genera.

The plants examined were collected in Dunklin County, Missouri.— By Mr. B. F. Bush, from the Varner river near

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* Here arises the question whether the stipe is always to the left or not. This I have found to be true in all my examinations of living material, though they were too limited to venture a positive assertion to that effect. Dry plants could give me no aid on this point since in them it seems impossible to determine which is the upper and which the lower surface of the frond.

Kennett, July 27, 1895, growing with *Lemna Valdiviana*, *L. minor*, *Spirodela polyrrhiza*, *Wolffia Brasiliensis* and *Azolla Caroliniana;* By Dr. O. Widmann, from the St. Francis river, October 5, 1895,— received at the Missouri Botanical Garden, adhering to the roots of *Jussiaea repens.*

WOLFFIA LINGULATA, Hegelm.

While on a brief visit in California during the past fall, one day late in September I discovered among other Lemnaceae growing in an irrigation canal an abundance of what afterward proved to be *Wolffia lingulata*, Hegelm. On October 7, 1895, I collected a large quantity of this mixture of aquatic plants which, with a little care, I was enabled to bring to St. Louis in good living condition and place in the Missouri Botanical Garden, where it has since continued to grow luxuriantly — affording abundant material for study, both for observations of growth habits and for anatomical investigations.

Wolffia lingulata, Hegelm. is a much shorter and broader species than the foregoing and, as its name indicates, is tongue-shaped. Like *W. gladiata* it is curved in the direction of a band but, unlike it, is not curved edgewise. It differs also in never forming the dense interlaced masses that *gladiata* does. This is impossible from the short and broad shape of the fronds. The young frond readily breaks away from its parent even before fully grown, so that no family grouping is ever found either. In the numberless specimens I have examined I have never yet found more than two * fronds united — the parent and offspring — though

* These observations were made on normal plants with normal conditions surrounding them. Later I found in one of my fish-globes, where I have my plants growing, a few instances of *three* fronds united, but this seems to be due to the fact that the plants had not been disturbed for several weeks, for the slightest handling readily broke the three apart. The plants of this globe were not in a healthy condition either — being kept in another greenhouse of different temperature and humidity from the others. However, the rule as stated above holds true for the plants as they are found in their natural growth.

younger fronds in all stages of development are to be seen in the pouches of both of these, wholly included within them. Again I have failed to find an instance where two fully grown fronds were connected — the offspring completing its growth after being set free and scarcely mature when it in turn casts its offspring. How many individuals one parent frond may give rise to I am unable to state, though I have observed as many as four in their various stages of development, all attached to the same matrix, which probably continues to successively develop more.

As before stated, the frond grows in a band-like curve, but instead of being flat as in *gladiata* it has the lateral margins at maturity upturned like the sides of a boat (pl. 65, f. 6). In these, too, the shape seems to be adapted for catching water currents and thereby being carried to distant points. When the water is disturbed the plants dive in all directions from the surface, and from their peculiar form assume a somersault or rotary motion — the direction of least resistance for their shape — then slowly rise to the surface again.* This power to float is due to the abundance of large chambers in the tissue of the basal portion of the fronds, filled with some gas (pl. 65, f. 5).

Wolffia lingulata was named and described by Dr. Friedrich Hegelmaier,† from material collected in Mexico by Louis Hahn in 1868. The plant is a thin frond, tongue-shaped and entire, with a rounded apex and a slightly oblique truncated base, which is split horizontally to form a triangular pouch, in the basal angle of which the budding of reproduction takes place (pl. 65, 1–5). This basal

* Another agency in so distributing the plants is a little crustacean much resembling a sand-flea. It swims to the surface and there attaches itself to the under surface of a frond. This added weight slowly sinks both to the bottom where the animal releases the frond and both again come to the surface — the frond appearing in a new locality, the animal to repeat its sportive manoeuvers.

† Hegelmaier: Die Lemnaceen, p. 132 (1868).

angle is seldom less than 60° or greater than 90°, making the pouch shallow as compared with the foregoing species. The budding takes place from a slightly elongated placenta or matrix situated on the upper surface of the lower wall of the pouch, and the young buds are produced in regular order from near the pouch angle (pl. 66, f. 2–6).

In developing, the young frond does not retain the same line of direction in growth as the parent assumes — the long axis of each crossing at an angle ranging between 160° and 175°. In all the specimens examined, looking at the upper surface in each case, the young frond was turned to the right, away from the stipe scar of the parent, which is, in every case, on the left-hand side and under the young frond. The proportional distance of this scar from the two marginal angles of the pocket varies slightly, but in no case did I find it so near the left-hand angle as to warrant the drawings of Hegelmaier* which show it at the left-hand juncture of the upper and lower walls. He also figures the rows of elongated cells which form the costa as being situated in this line of juncture and extending from the scar to the basal angle of the pocket. My observations have shown the costa to be situated within the lower wall of the pouch, about one-fourth the width of the pouch from the left-hand angle formed by the juncture of the two walls and never coinciding or parallel with it. In younger plants the stipe scar and costa are nearer the angle and in older plants they are farther away (pl. 66, f. 7–9).

In structure the plant is made up primarily of an upper and a lower plate of epidermal tissue, each composed of a single layer of cells. The plates are united at the margins of the frond and connected in the interior by walls of upright cylindrical cells (pl. 65, f. 7). These walls are but one cell thick and one cell high toward the margin

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* Hegelmaier: Die Lemnaceen, t. iv. f. 31, 32 — (1868); Fl. Bras. fasc. 76, pl. I. f. iii. f. 1, 2, 4, 5 — (1878).

but two cells high in the interior. The large cavities formed by these walls and the two epidermal layers are termed "air cavities" by Hegelmaier, and the gas they contain enables the plant to float. This cavernous tissue extends from one-half to two-thirds the length of the frond, from the base. After a long, careful search I was unable to find any openings connecting these cavities with the exterior, so it is hardly probable that the gas in them is free to circulate with the air at the surface of the water. All searches for stomata were fruitless.

The epidermal cells are usually hexagonal and slightly elongated in the direction of the long axis of the frond. The air cavities are of the same shape and similarly lengthened. Both the upper and lower walls of the pouch are two cells thick except in the costa, which is increased to several cells in thickness. In the stipe and costa the cells are much elongated, prism-form with either square or wedge-shape ends, arranged in chains. From the point where the stipe joins on the frond these chains of elongated cells spread out flabelliform and the cells gradually shortening and broadening merge into the regular hexagonal form in the epidermis (pl. 65, f. 9). However, a few chains go direct to the base of the pocket and there join, through the matrix, with the stipes of the young fronds, forming a continuous chain of these ligneous-like cells throughout the generations (pl. 65, f. 11). In view of this fact the costa perhaps ought properly to be considered the axis of the plant and the frond merely as epidermal tissue modified to perform the functions of obtaining and utilizing food.

Quite regularly distributed over both surfaces are epidermal cells, somewhat smaller than those surrounding them, with granular yellow contents; they occur also in the elongated cells of the costa. These are the so-called pigment-cells of Hegelmaier. Their function is as yet unexplained (pl. 65, f. 8).

The occurrence of this species in this isolated point, far away from its first reported habitat, separated from it by

high ranges of mountains and connected with Mexico by water only through the Pacific Ocean, brings up the interesting question as to how it came to be there. How is it disseminated otherwise than by water currents? The most probable theory seems to be that the plants were carried from their southern home,— considering Mexico their original habitat,— on the feet of migratory aquatic birds. This is very plausible from the fact that if one's finger is thrust into a mass of the plants, as they are floating on the water, and then withdrawn, scores of plants will be found adhering to the surface of the finger. This is probably the case also with the legs and feet of ducks and geese. These birds, rising from the lakes of the region of central Mexico, where *Wolffia lingulata* is reported as growing in abundance, may start on their long northward journey, and their feet folded among the feathers would afford a considerable protection to a number of plants which might otherwise be dried to death by the rapid passage of the bird through the air. Wherever the bird might stop to rest in northern lakes, or streams, some of these plants would be washed away from it and, if the climatic conditions were favorable, would continue their natural growth. However, it is highly probable that later these plants will be found to occur at many intermediate points between the City of Mexico and the Californian locality, in which case the exposure to the air in the migration of birds would not necessarily be of so long duration. In either case the plants must have come over the high range of mountains to the south of the newly reported habitat.

My plants were found about three miles west of Bakersfield, California, in what is known as the Emery canal or Artesian ditch. Concerning this canal, my brother, W. O. Thompson, of that place, writes on Feb. 2, 1896: "Its origin is similar to that of an artesian well. The water comes from the Kern river; but it goes down through the coarse sand and rises again some distance from the river. The ditch went dry last season." Associated with

the *Wolffia* was an abundance of *Lemna Valdiviana minima*, Hegelm., and a lesser quantity of *Lemna minor* L.

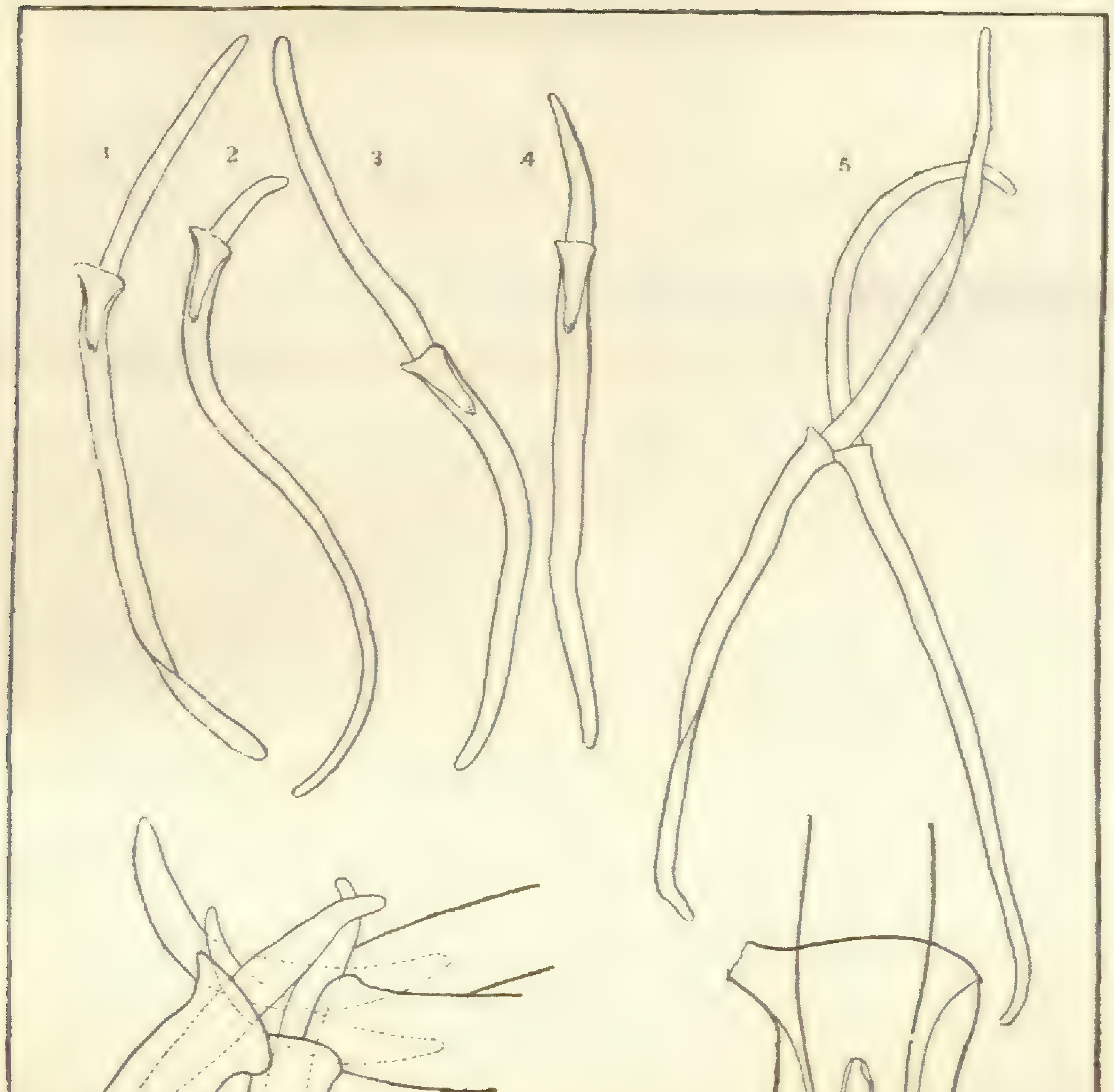
EXPLANATION OF PLATES ILLUSTRATING THE LIGULATE WOLFFIAS OF THE UNITED STATES.

The figures were drawn by Miss Grace E. Johnson from sketches prepared by the author.

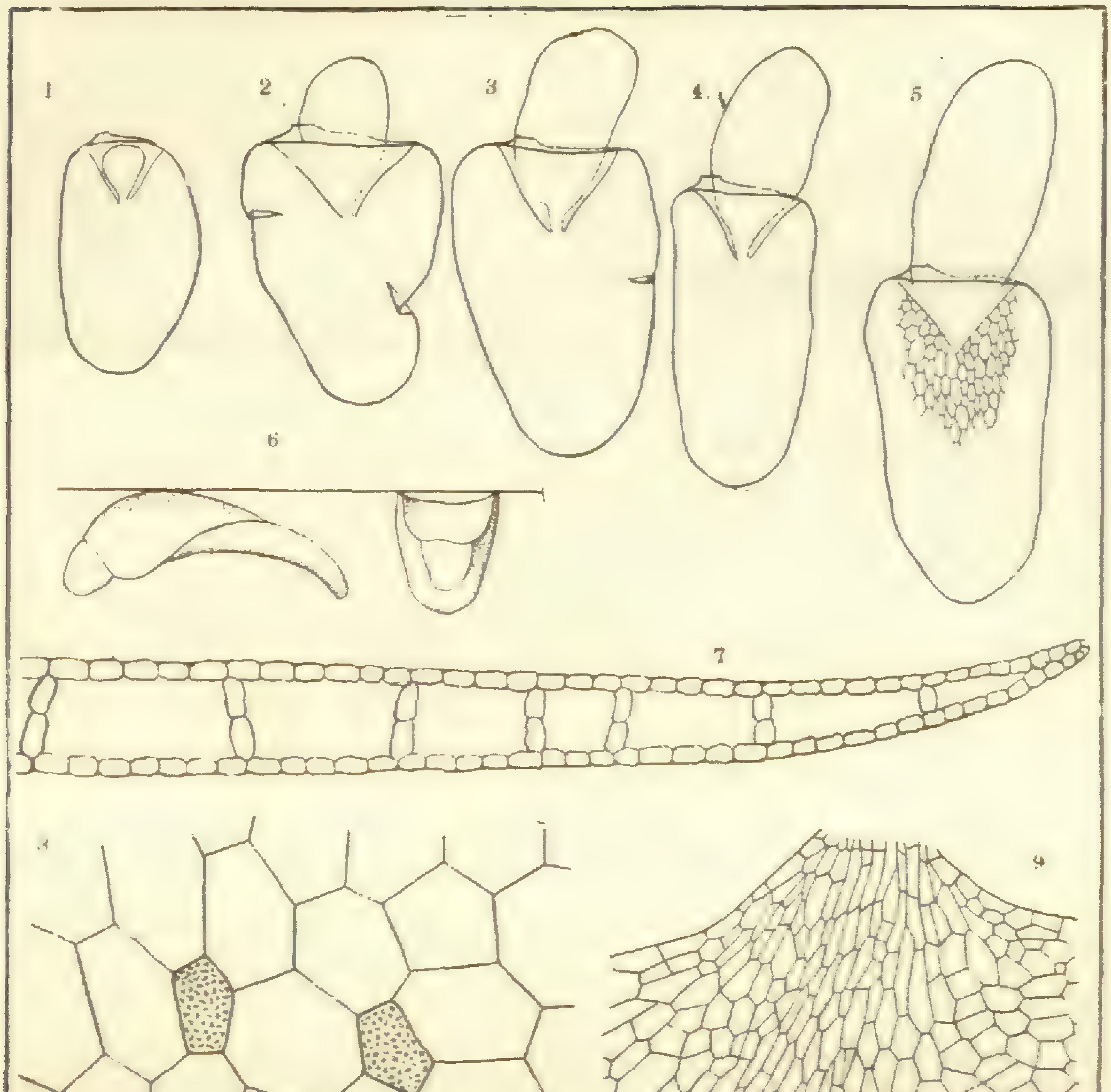
Plate 64. *Wolffia gladiata Floridana* J. D. S.— 1, 2, 3, 4, 5, Mature plants with offspring, × 8; 5, three generations of fronds attached; 6, bases of a group of attached fronds showing the formation of so-called "families;" 7, base of frond showing the pocket with two offspring attached to its matrix, the older of which also has a young individual in its pocket, × 36; 8, a portion of the upper epidermis next the margin showing epidermal cells with pigment cells, × 145; 9, a group ("family") of plants, × 5.

Plate 65. *Wolffia lingulata* Hegelm.— 1, A frond just separated from its parent, × 8; 2, 3, 4, 5, frond showing variations in shape and line of direction in growth of young fronds, × 8; 5, shows position and relative size of air cavities; 6, normal position of fronds in water, × 5; 7, portion of transverse section of frond showing epidermal layers, partition walls and air cavities, × 125; 8, portion of epidermal tissue showing two pigment cells, × 320; 9, stipe scar and end of costa, × 75; 10, epidermal cells showing general form and relatively smaller pigment cells. Beneath are shown chains of cells forming walls of air cavities — chlorophyl grains drawn in these to better bring out these partition cells, × 200; 11, portion of costa about midway between stipe-scar and basal angle of pouch, × 75.

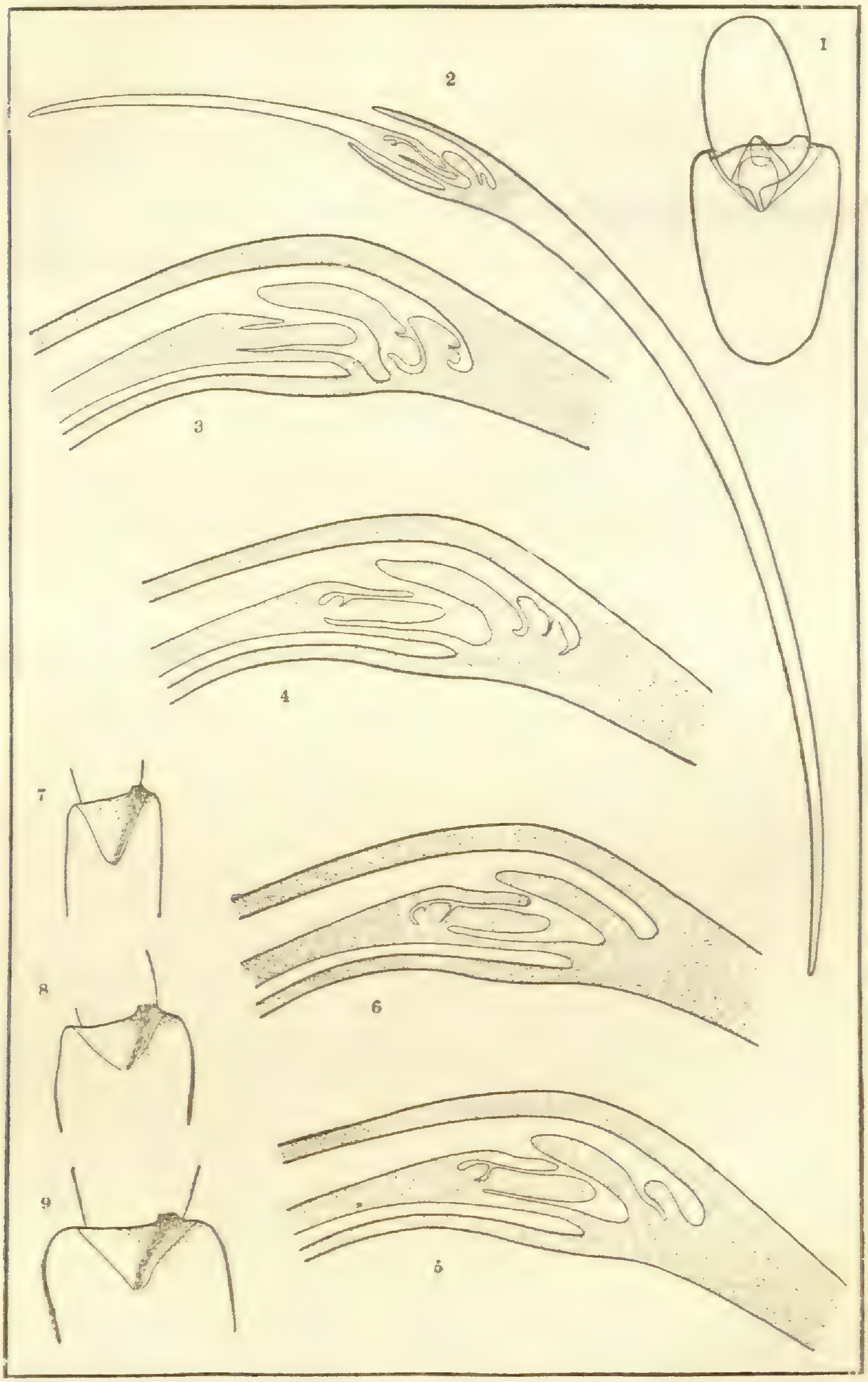
Plate 66, *Wolffia lingulata* Hegelm.— 1, Plant showing offspring in various stages of development and their respective positions, under surface, × 8; 2, longitudinal section of plant through the reproductive pouch showing position of offspring from a lateral view, × 16; 3, 4, 5, 6, a series of longitudinal sections through the reproductive pouch like last but more enlarged, × 125; 7, 8, 9, diagrams representing the position of stipe and costa, also transition of prismatic cells,— under surface of frond, × 8.



WOLFFIA GLADIATA, VAR. FLORIDANA.



WOLFFIA LINGULATA.



WOLFFIA LINGULATA.

THE VALUE OF A STUDY OF BOTANY.*

BY HENRY WADE ROGERS, PRESIDENT OF NORTHWESTERN UNIVERSITY.

When I accepted the invitation to speak at this banquet, the Chancellor of Washington University, through whom the invitation had been most courteously conveyed, took the trouble to have sent to me the Annual Reports of the Garden containing the addresses which have been delivered on occasions similar to this. I, of course, felt it my duty to read every one of those addresses, and when I concluded the last of them I was in doubt as to the real intentions of the Chancellor. For if he had desired to alarm me, to create a self-distrustful spirit within me, and make me shy, he could not have taken a more effective means to that end. I acquit the genial and distinguished gentleman of having cherished any such malicious design. I confess that after reading those addresses I had various and sundry misgivings as to whether after all I had any message to bring to you that was worthy of the occasion, and not a repetition of what had already been said. But notwithstanding I am exceedingly glad to be with you, and to add my tribute to those which others have paid to a man whom we all of us recognize as having been a great public benefactor. It seems to me that this splendid city of the great Mississippi Valley can never have numbered among its citizens a man more deserving than Henry Shaw to have his name spoken with admiration and honor. The people whose home is here have on other occasions been told how

* An address delivered at the Sixth Annual Banquet to the Trustees of the Missouri Botanical Garden and their guests, May 17, 1895.

much Henry Shaw was deserving of their respect, and that, to quote the language of another, for the reason Antony said Cæsar deserved the loves of the people of Rome—

> "He hath left you all his walks,
> His private arbours, and new planted orchards,
> On this side Tiber; he hath left them you,
> And to your heirs forever; common pleasures,
> To walk abroad, and recreate yourselves."

I have not, however, left important duties and traveled several hundred miles simply to eulogize what this man did for the city in which he made his home. What he did was not local. It was not confined to this city, nor to this State, nor to the United States. He gave to the world the means whereby the boundaries of human knowledge might be enlarged, boundaries that extend beyond those of any city, State, or country. And so it happens that every year since he died men have been willing to come from Universities in the North, the South, the East, and the West in order that they might pay tribute to one who has rendered service to the race.

The name of Henry Shaw is enrolled in the Golden Book of the Republic. And for years to come, whenever in any portion of our country mention is made of the great philanthropists of the United States his name will be spoken with honor. Verily wheresoever in the whole world men discuss what has been done to enlarge the horizon of knowledge there also this that this man hath done deserves to be told for a memorial of him.

"For myself," said the great Spinoza, "I am certain that the good of human life cannot lie in the possession of things which, for one man to possess, is for the rest to lose, but rather in things which all can possess, and where one man's wealth promotes his neighbor's." The good of the life of Henry Shaw does not lie in the fact that he amassed millions which others lost, but that he so possessed them as to enable others to share with him in the benefits which

accrued therefrom, and that dying he devoted them to a purpose which would promote the knowledge, the well-being and the pleasure of those who were to come after him.

It is Ruskin, I believe, who declares that the first of all English games is making money. He announces that it is an all-absorbing game, that we knock each other down oftener in playing it than at football, that it is absolutely without purpose, and that no one who engages heartily in the game ever knows why. The game is not played to get money to do anything with. But the player gets it only that he *may* get. And if you ask him, "What will you make of what you have got?" he answers, "Well, I'll get more."

Now we all know that money-making is a game that is very much played in the United States. England has not a monopoly of it by any means, and while we have not played at the game as long as they have on the other side, we have been in some respects more successful at it, and have made our country the richest nation of the world. I note, however, this difference between the game as played in England and America. More of our players have seemed to know why they were in the game, and what they wanted the money for. More have played that they might get the money to do something with and fewer that they might simply get more. The result has been that our country has produced more splendid philanthropists than any other in the world, and our generation has in this respect excelled any of the generations that have preceded it. It will have to be confessed, I fear, that some of our munificent givers have not always been particular as to the manner in which they reached the goal, and that they have sometimes won by as foul "slugging" as ever disgraced a game of football. It is, however, to be said to the honor of Henry Shaw that he made his money in a legitimate manner and devoted it all to a noble purpose. And we are able here to-night to commend what he did as an example to the youth.

We may tell them to make money as he did that they may help, as he did, in the uplift of the race, and let us bid them not to make money simply that they and their descendants may belong to the luxuriously-living idle class whom Froude likens to the Olympian gods, condescending to show themselves in their Empyrean, and saying to their worshipers: "Make money, money enough, and you and your descendants shall become as we are, and shoot grouse and drink champagne all the days of your lives."

A few years ago and the study of botany was regarded merely as a sort of elegant accomplishment, to be studied appropriately by young women and dilletante young men.

Now it has become recognized as a serious occupation worthy of all the encouragement that the best of our universities can give to it. Its study commends itself alike to the class who demand that the end of education shall be the attainment of culture, and to that other class who are demanding that education shall be practical and who would apply the principle of utility to every branch of study pursued. Its study has intellectual value and stands for culture. It also has economic value and stands for utility. If it simply possessed economic value its place would be in the technical schools. But because it has an intellectual and culture value it is entitled to a place in the curriculum of the colleges of liberal arts. That it is assigned to such a place in all of our institutions for the higher learning is evidence of the fact that educators are agreed in believing that the study of this subject affords valuable intellectual training, and that it is an aid to culture.

In 1869 Mr. Huxley declared that he conceived it would be one of the greatest boons which could be conferred upon England if henceforward every child in that country should be instructed in the elements of botany, and of physics. And he stated that he named these two subjects in preference to any other of the natural sciences because he was convinced that every educational advantage which training

in physical science could give was obtainable from their proper study.

The old notion that there is but one road to culture, and that the avenue of Latin and Greek, we know to be no longer tenable. Mr. Arnold, who has been called the chief apostle of culture, tells us that the meaning of culture is to know the best that has been thought and said in the world, and that the essence of culture is a criticism of life. If we accept this as an explanation of what is meant by culture then I say with Huxley that "An army, without weapons of precision and with no particular base of operation, might more hopefully enter upon a campaign on the Rhine, than a man devoid of a knowledge of what physical science has done in the last century, upon a criticism of life."

I approach this subject free from the bias which one might have who had been trained in sciences. My own education was in the classics. But I am a firm and devout believer in the intellectual and culture value of the study of the sciences.

The intellectual value of the study of botany probably differs but little from that which attaches to the study of any of the natural sciences. The process which is employed is that of induction, and the student must exercise his faculties of observation and comparison. Having observed and compared, he draws general conclusions from the particular cases. The mental discipline which this involves is very different from that which results from a study of the languages, or history, or mathematics. I can only repeat what has been many times pointed out by others, that in the study of languages and history the facts are accepted on the evidence of authority and tradition, while in mathematics the student has given him a few simple and self-evident propositions from which he deduces certain necessary and definite conclusions. On the other hand, in the study of botany, zoology, and other of the natural sciences, nothing is taken for granted; the student observes for himself the

facts, and practices his intellect in the most complete form of induction. The exercise of the intellectual faculties which this involves tends, more than does the study of languages or history or mathematics, to develop originality of mind and exactitude of knowledge. The mind is trained to attention and accuracy, the two mental qualities in which all mankind are said to be more deficient than in any other whatever. To do good work in botany requires great exactitude, patience and judgment.

Thiselton Dyer in an address before the British Association for the Advancement of Science, made in 1888, speaking of the intellectual value of the study of botany, declared that he did not doubt that precisely the same qualifications of mind which made Jeremy Bentham a great jurist, enabled his nephew to attain the eminence he reached as a botanist. And he added that "as a mere matter of mental gymnastic, taxonomic science will hold its own with any science." John Stuart Mill, who himself possessed a competent knowledge of botany and was therefore a competent judge of the intellectual value of the study, tells us that the proper arrangement of a code of laws depends on the same scientific conditions as the classifications in natural history, and that there could not be a better preparatory discipline for that important function than the principles of a natural arrangement, not only in the abstract, but in the actual application to the class of phenomena for which they were first elaborated, and which are still the best school for learning their use. He also informs us that of this Jeremy Bentham was perfectly aware, and that his Fragment on Government contains clear and just views on the meaning of a natural arrangement which reflect directly the influence of Linnaeus and Jussieu.

The study of botany deserves to be encouraged because of the pleasure which a knowledge of the science brings within reach of those who are its votaries. The trees, the shrubs, the flowers are a new delight, and a constant pleasure to those who know and can interpret the story of

their existence. We study literature because we find in it a ministry of joy which gladdens, invigorates, and rests us. But the trees and the flowers constitute a ministry of joy, and to those who really know them they are companions ministering to the higher and purer delights of life, and voicing, like some old Gregorian chant, the praise of God. They praise him and magnify him forever — even as it has been written: "O all ye green things upon the earth, bless ye the Lord; praise him and magnify him forever."

They speak to those who know them a language full of meaning. It was Wordsworth, I believe, who said: "To me the meanest flower that blows can give thoughts that often lie too deep for tears."

Huxley has advocated the study of natural history because it leads us to seek the beauties of nature instead of trusting to chance to force them on our attention. "To a person," he says, "uninstructed in natural history, his country or seaside stroll is a walk through a gallery filled with wonderful works of art, nine-tenths of which have their faces turned to the wall. Teach him something of natural history, and you place in his hands a catalogue of those which are worth turning round."

The study of botany deserves encouragement too for what it has already accomplished and is capable of hereafter accomplishing for agriculture. Within the memory of men here present the theory of agriculture has been revolutionized by virtue of the better knowledge of the subject which the botanists together with the chemists have ascertained and diffused. I shall not undertake to set forth at length what has been accomplished in this respect. But I wish to say that the new fields of botanical research which are now being developed give promise of results of the greatest economic importance. I refer to the study of that class of plant diseases which are due to parasitic bacteria, and to which attention was first called about 1880, by a distinguished botanist of the State from which I come. These investigations have disclosed well

defined diseases of bacterial origin in tomatoes, potatoes, melons, oats, corn, sorghum, beans, beets, peas, and apples. If the science of botany shall reveal the nature of such diseases and provide a remedy whereby the life of the plant shall be preserved and a decrease in the yield prevented, it will surely render a service the value of which it would be difficult to estimate. And it is gratifying to know that the larger part of what has been accomplished along this line has been due to American botanists.

The botanist has already made it known that the "blights," "mildews," "rusts," "smuts," etc., found on the various kinds of vegetation are themselves true plants, and that they are limited in their development like other organic species by certain conditions and surroundings. Some of these limitations he has already made known, while others remain to be ascertained by him. While the botanist has not yet been able to suggest the means of effectually destroying in all cases the injurious fungi, yet he has been able to make most valuable suggestions whereby much of the loss formerly entailed has been very considerably reduced. In some cases he already knows how to exterminate the parasites and in others how to prevent their ravages. As to the economic value of what he has already accomplished, take the one subject of oat smut. In a publication issued under the authority of the United States Department of Agriculture in 1892, it was estimated that the net gain to the farmers of this country between 1880 and 1890 (from a system of treatment of oat seed now known which would have produced a crop free from oat "smut") would have been not less than $162,000,000.

One object Mr. Shaw had in establishing a School of Botany in connection with the Botanical Gardens was, as stated in the will, to promote the application of the science of Botany to Arboriculture. The cultivation of trees on scientific principles promises to become a matter of great economic importance — even to us in the United States. At the present rate of consumption, according to the Chief

of the United States Department of Forestry, we have hardly one hundred years of forest supply in sight, and certain kinds of supplies are already beginning to give out. The end of even the white pine resources is said to be plainly in view in both this country and Canada. It is desirable to extend our knowledge of the principles of scientific forestry. Forests have an economic value as a source of fuel, as a source of timber, and for their influence on agriculture. We know that they effect climatic conditions, and that the amount of rainfall is influenced by the forest area. Too much rain is unfavorable to farm crops, and too extensive forests may prove disastrous to agriculture. Science teaches that where the rainfall is over forty inches the forest area should not be increased. This important science of forestry rests on a knowledge of botany, and the botanists are "the apostles of forestry."

Again, the study of botany deserves encouragement because of the intimate dependence upon it of the science of medicine. The art of preparing and compounding medicines with reference to their physical properties involves a knowledge of the different parts of plants, the method and season of their collection, and of their desiccation and preservation. It is not too much to say that the student of medicine who fails to possess a sound knowledge of the great truths respecting vegetable as well as animal life cannot be other than empiric.

One of the great educational needs of our country is that of a thoroughly equipped School of Botany. There is no place in the United States where such a school could be better developed than here in connection with the Washington University and these magnificent Gardens, unsurpassed by any Gardens in the world unless it be by the famous Kew Gardens of London. What is needed is an adequate teaching force with specialists in each of the various departments of botany. This would make your University easily the great center for botanical investigation and instruction, not only for the United States but

for the world. To-day the German Universities are far in advance of the English and American Universities in the advantages which they offer, but with a little effort your own University might easily be put in the lead.

Over in India on the banks of the Jumna stands what is pronounced to be the most wonderful structure ever erected by man. It is a thing of beauty and a joy forever. It stands in the center of a spacious park, and on a marble terrace thirty feet high. It is built of white marble. Its dome shines like a globe of silver and at the top is a golden crescent. It is approached through a gateway of red sandstone and the avenue from the gate to the tomb is said to contain eighty-four fountains, and a large marble reservoir bordered by rows of cypress trees. The songs of birds are said to mingle with the rippling of the fountains, and the air is described as freighted with the delicious fragrance of the rose and the orange. Wrought into this magnificent Taj are thousands of pounds of opals, other thousands of pounds of rubies. Woven in the splendid designs are still other thousands of pounds of emeralds and thousands of sapphires, of carnelian, and of turquoise. Thirty-five different kinds of carnelian are said to be used in a single leaf of a carnation, and one blossom not larger than a dollar contains twenty-three gems, while a single flower is made of three hundred different stones. The beauty of it surpasses description and the expensiveness of it is beyond apprehension. More millions have been lavished on it than on any university in Europe or America. All this treasure was lavished simply to build a tomb. It adds nothing to the sum of human knowledge, and save as it is a memorial of love and a monument of beauty it contributes nothing to the betterment of mankind. I cannot help thinking how much better it would have been to have slept in an unpretentious sepulcher and devoted these millions as Shaw did his to that which would have advanced the knowledge, the pleasure, the health, and the wealth of mankind.

CATTLEYA LUTEOLA

LIBRARY CONTRIBUTIONS.

THE STURTEVANT PRELINNEAN LIBRARY.

In 1892 Dr. E. Lewis Sturtevant, of South Framingham, Mass., a gentleman who, through his studies of agricultural botany, had become greatly interested in the records of wild and cultivated plants preserved in the early Herbals, Natural Histories, and Medical Botanies, presented to the Garden a large collection of such works which he had been accumulating for a period of years, attaching no conditions to the gift, but suggesting that it would be well if the collection, together with other works of the same period, might occupy a separate alcove, the contents of which should ultimately be published in a catalogue, in order that students might know of the existence of these works at the Garden.* This suggestion was at once complied with, so far as the arrangement of the books is concerned, and a separate card catalogue of the Prelinnean library was prepared, but with Dr. Sturtevant's consent its publication has been deferred until the present time for various reasons.

Even a casual inspection of the Prelinnean shelves shows that no study of the cultivated plants of the present time can be at all complete unless the minute and painstaking records of the herbalists are consulted, for, with so mutable a class of plants as our flowers, vegetables, farm crops and fruits, the tracing of their history under cultivation is no small part of their study. What is asserted of cultivated plants, among which it has been stated by one of their most distinguished American students that the artifi-

* Fourth Report, 14.

cial evolution of species is being daily effected under our eyes,* is also true, though to a less degree, of the native plants of temperate regions, since the knowledge of wild plants long antedates the period of Linnaeus; which, for practical reasons, is commonly held to mark the beginning of modern botany.

In the classification of a botanical library, the modern period is usually held to begin with the introduction of binomial nomenclature in the first edition of the Species Plantarum, published by Linnaeus in 1753, and this date is, therefore, made the limit of the Prelinnean alcove, at the Garden. Linnaeus, himself, however, had published many books before this date, and these should properly form a part of the Sturtevant library; but for convenience it has seemed better to form a special group of Linneana.

In attempting even so simple a task as cataloguing a collection of early books, greater difficulties are met with than in the case of most modern books. True, the *nom de plume* was less used then than now; but anonymous works were numerous, and the title of Parkinson's Paradisus Terrestris leads to the suspicion of punning on both subject and author's name in other cases. Frequently, also, letters or minor papers by various authors are either printed with or bound in many of the earlier books, making frequent cross references necessary. And these difficulties are greatly increased by the frequent use of borrowed illustrations, without indication of their source; the numerous editions, sometimes greatly differing, sometimes with illustrations more changed than the text, printed for some of the early writers; their many commentators, often with multiple editions of their commentaries; the simultaneous publication of identical or slightly differing editions in different countries; and the recomposition of reissues of a given edition, giving rise almost inevitably to minor differences which, in the eyes of the bibliophile, are of considerable importance.

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* Bailey: Science, Dec. 20, 1895, 834.

Not infrequently, too, the text and figures are not in agreement.

In the preparation of the following catalogue, the preliminary work on which was done by Mr. J. C. Bay, while he was in the employ of the Garden, considerable use has been made of Von Haller's Bibliotheca Botanica, 2 vols., 1771–2; Meyer, Geschichte der Botanik, 4 vols., 1854–7; Reuss, Repertorium Commentationum a Soc. litt. edit., 3 vols., 1801–3; Sachs, Geschichte der Botanik, 1875; Seguierius and Bumaldus, Bibliotheca Botanica, 1740; Sprengel, Historia Rei Herbariae, 2 vols., 1807–8, and Geschichte der Botanik, 2 vols., 1817–8; Warming, Den Danske Botaniske Literatur, 1881; Winckler, Geschichte der Botanik, 1854; and Winther, Literaturae Scientiae Rerum Naturalium in Dania, Norvegia & Holsatia, 1829. The principal labor of reading proofs and verifying the entries by comparison with the works has fallen to Mr. C. E. Hutchings. Grateful acknowledgment is also made to the donor of the collection for assistance rendered with many obscure titles, and for reading and annotating the proofs of the catalogue.

The intention has been to spell authors' names as on the title page of each work, except that oblique cases are uniformly reduced to the nominative. Cross references facilitate the collation of the works of a given author who may have published in several languages, modifying his name to suit the idiom of each, — a very frequent custom with the early writers. Translators' or changed editions are catalogued under the author, with cross references under editor or translator. Under each entry the titles are arranged chronologically, except that all editions of a given work under each name come together. Translations or editions of works originally published prior to 1753, are included in the catalogue, even though of recent publication, and though the originals may not be in the library.

Where several works are bound together, the volume is placed on the shelves under the one first found on opening it, each of the others being indicated in the catalogue as

"bound with ——," and represented in its proper place on the shelves by a dummy bearing a similar inscription. A small number of folios too large for the regular shelves are arranged in a separate alphabet, but represented in their proper places by dummies indicating this fact. Anonymous works, the author of which could be ascertained, are catalogued and arranged under the author's name, with cross references. Other anonymous works are arranged under the first catchword of the title. The relatively few works not derived from the Sturtevant donation, are marked by an asterisk.

Throughout, the size indication is based on the size rules of the American Library Association, as indicated by Watson's cataloguer's size card, published in 1889, by the Library Bureau of Boston.

William Trelease.

Aalborg: * Medizin eller Laegebog. — 1638. 1 vol. T. (15x8.5). — Imperfect.

Abvalj Ibn-Tsina qui hactenus perperàm dictus est **Avicenna**: Canon medicinae interprete & scholiaste Vopisco Fortvnato **Plempio**. Tom. I. librum primum & secundum canonis exhibens, atque ex libro quarto tractatum de febribus. — Lovanii, 1658. 1 vol. F. (31.5x19.9).

Another **Account** of cider from a person of great experience; — See EVELYN, Pomona, 1670, p. 65.

a Costa, Christophorus; — See COSTA.

Acosta, Ioseph: The natvrall and morall historie of the East and West Indies. * * * Written in Spanish by Ioseph Acosta, and translated into English by **E. G**[**rimestone**]. — London, 1604. 1 vol. D. (18.7x14).

Addison, Joseph; — See HOWE, WALTER.

Aegineta, Pavlvs: Pharmaca simplicia, Othone **Brunfelsio** interprete. Idem De ratione victvs Gulielmo **Copo** Basiliensi interprete. In Pavlvm Aeginetam de simplicibus iuxta ac de ratione victus, index tum utilis, tum necessarius. — Argentorati, Sept. 1531. 1 vol. S. (16.3x11.3).

Africanus, Julius; — See AGRICULTURAL PURSUITS.

Les **Agremens** de la campagne, ou remarques particulieres sur la construction des maisons de campagne. — Leyde and Amsterdam, 1750. 1 vol. sq. O. (24.8x19.7).

Agricola Ammonius, Ioannes: Medicinae herbariae libri dvo. — Basileae, 1539. 1 vol. T. (14.5x9.3).

Agricultural Pursuits (*ΓΕΩΠΟΝΙΚΑ*). Translated from the Greek, by the Rev. T. Owen. — London, 1805-1806. 2 vols. nar. O. (23.3x14).

Albertus Magnus: Ex ordine praedicatorum de vegetabilibus libri VII, historiae naturalis pars XVIII. Edi-

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Durante, Castor: Hortulus Sanitatis. Das ist ein heylsam[es] vnd nützliches Gährtlin der Gesundtheit. In welchem alle fürnehme Kräutter die so wol in den beyderley Indien als an allen andern Orten der Welt zu finden in einer wunderbaren Kürtze werden beschrieben. * * * Nunmehr aber in vnsere hoch Teutsche Sprach versetzt durch Petrum **Uffenbachium**. — Franckfort am Mäyn, 1609. 1 vol. O. (20x17.6).

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Fabricius, J. A.; — See SCRIPTORES REI RUSTICAE, i.

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Holland, Philemon;—See PLINIVS, 1634.

Isaac Ben **Honain**; — See NICOLAUS DAMASCENUS.

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ab **Horto**, Garçias: Aromatvm, et simplicivm aliqvot medicamentorvm apvd Indos nascentivm historia: Primùm quidem Lusitanica lingua διαλογηκῶς conscripta, à D. Garçia ab Horto, * * * Deinde Latino sermone in Epitomen contracta, & iconibus ad viuum expressis, locupletioribus'que annotatiunculis illustrata à Carolo **Clvsio** Atrebate. Qvarta editio. * * *—Antverpiae, 1593. 1 vol. nar. S. (16.9x11.2).

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tions in a copy of the book which formerly belonged to Professor E. Nolte, to which Mr. Bay has made numerous additions. For an account of the annotated copy, see the Botanische Zeitung for 1890, p. 382. See also Warming, Botanisk Tidsskrift, xii, 1880, p. 52, and Bay, ibidem xvii, 1890, p. 323.— A short manuscript biographical sketch of Kylling has also been contributed by Mr. **Bay**.

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1706. Vols. I (pp. 1–308) – II (pp. 311 [title-page, pp. 309–10] – 679). 2 vols. in one. nar. S. (16x9.6).

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This edition is merely a collection of the figures from the Kruydtboeck (1581), and was not arranged by Lobelius himself. The Plantinian book-firm (see Meyer, Gesch. iv, p. 364), in a short preface, gives Dr. Severinus **Gobelius**, a Dane, credit for the arrangement of this edition. Christ. Plantinus, who dedicated the preface to Severinus Gobelius, writes: "nostra haec editio tibi merito debetur."

de L'Obel, Matthias: Matthiae de L'Obel * * * stirpium illustrationes. Plurimas elaborantes inauditas plantas subreptitiis Joh: **Parkinsoni** rapsodiis (ex codice MS insalutato) sparsim gravatae. Ejusdem adjecta sunt ad calcem Theatri Botanici Ἁμαρτήματα. Accurante Guil: **How**, Anglo.— Londini, 1655. 1 vol. sq. D. (19.5x15.5).

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Lvsitanvs, Amatvs; — See DIOSCORIDES.

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Lynceus, I. T.; — See HERNANDEZ, FRANCISCUS.

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[**Macer Floridus**]: De herbarvm virtvtibvs Aemilii Macri Veronensis elegantissima poësis, cum succincta admodum difficilium & obscurorum locorum, D. Georgii **Pictorij** Villangani. * * *. Cum carmine de herba qvadam exotica, cuius nomen mulier est rixosa, eodem D. Georgio **Pictorio** Villingano autore.— Basileae, 1581. 1 vol. S. (16.2x10.4).

[It is not known that Macer Floridus was the writer of this poem, nor even that this is the name of a person. The suggestion of Pictorius that the author was the celebrated Roman poet Aemilius Macer results from a confusion of names. The correct suggestion is evidently that of Meyer (Geschichte iii, p. 429), who believes that Macer Floridus is the title of the book and not a personal name].

Macer Floridus: De viribus herbarum una cum Walafridi **Strabonis**, Othonis **Cremonensis** et Ioannis **Folcz** carminibus similis argumenti, quae secundum codices manuscriptos et veteres editiones recensuit, supplevit et adnotatione critica instruxit Ludovicus **Choulant**. Accedit anonymi carmen Graecum de herbis, quod e codice Vindobonensi auxit et cum Godofredi **Hermanni** suisque emendationibus edidit Iulius **Sillig**.— Lipsiae, 1832. 1 vol. O. (21.2x13.2).

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Martyn, Joannes: Historia plantarum rariorum.—Londini, 1728. 1 vol. F°. (53.2x37.1).

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corporis arborei explicatio breuis: vbi de earundem nutritione.—Lvtetiae, 1560.—Bound with **Mizaldus**, Alexikepvs.

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Editors: I, Johannes **Casearius** and Arnoldus **Syen**; II, Johannes **Casearius** and Joannes **Commelinus**; III, Johannes **Munnicks** and Johannes **Commelinus**; IV, Johannes **Munnicks** and Joannes **Comelinus**; V, Johannes **Munnicks** and Joannes **Commelinus**; VI, Theodorus **Janson** and Joannes **Commelinus**; XI and XII, Abrahamus **a Poot** and Ioannes **Commelinus.**

The author's name, in the several parts, is variously spelled Henricus van Rheede, van Draakenstein; Henricus van Reede, tot Draakestein; Henricus van

Rheede, tot Draakestein; Henricus van Rhede tot Draakestein; Henricus van Rheede tot Drakestein.

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